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MISSION OPERATIONS PLAN NIMBUS A

JUNE 1964

GODDARD SPACE FLIGHT CENTER
GREENBELT, MD.

MISSION OPERATIONS PLAN

NIMBUS A

June, 1964

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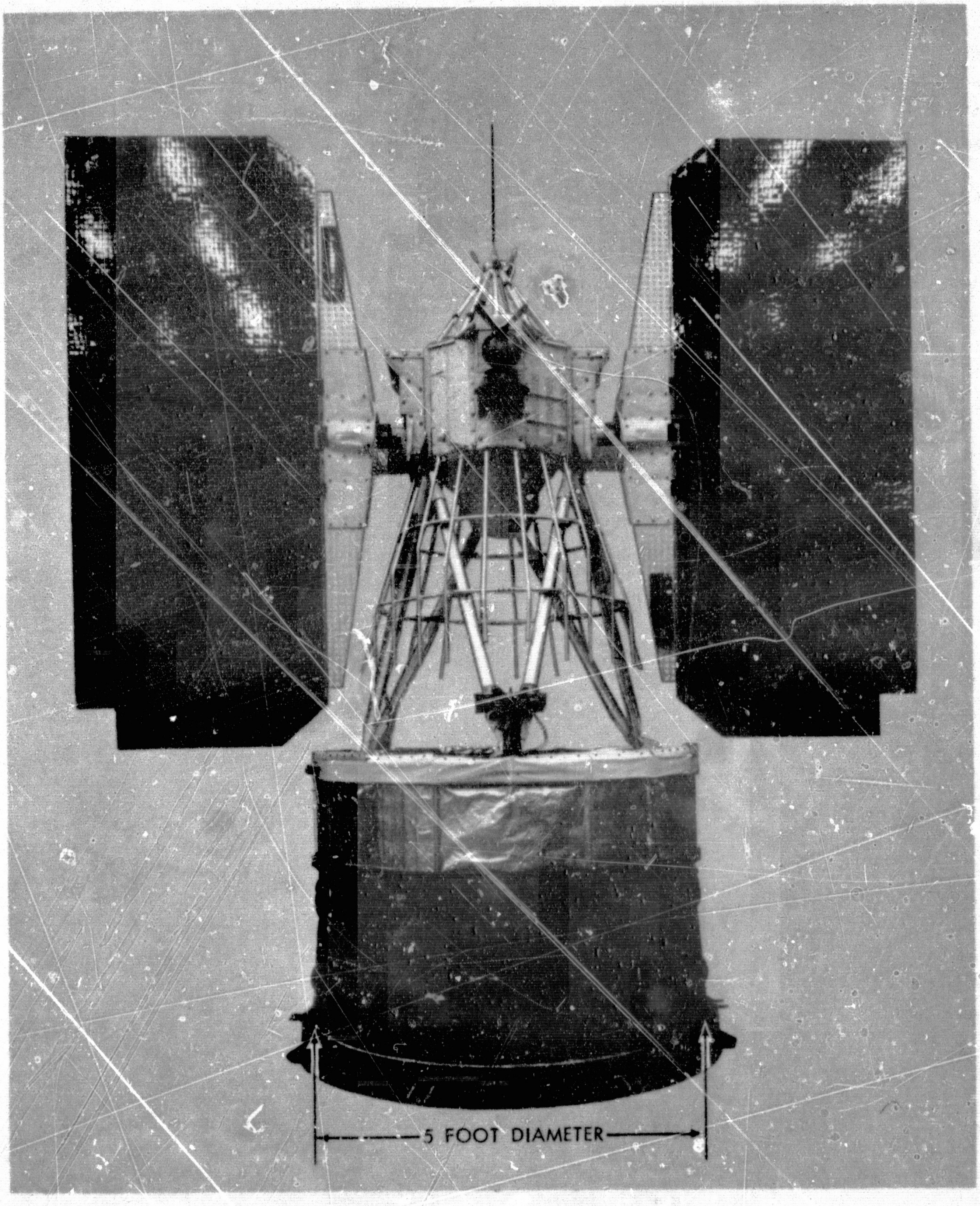

Frontispiece – Nimbus A Spacecraft

FOREWORD

The Nimbus A Mission Operations Plan outlines and defines the activities and responsibilities required in all major functional areas of the Nimbus A meteorological satellite system.

Because the Nimbus A program includes the spacecraft and the entire tracking, data-acquisition, and data-handling complex, the usual GSFC Operations Plan, the project Mission Plan, and the Early Orbit Determination Plan have been combined in a single document. Events and activities are presented in each part of the plan as required by each operating element; milestone events may be repeated in other parts for information.

Part I, Project Summary, gives a brief description of all of the elements of the Nimbus program, each of which is described in detail in later parts of the plan. Part II shows the project organization and lists a directory of individuals and assignments.

Part III describes spacecraft and vehicle operations during prelaunch, launch, and postlaunch phases. Part IV, GSFC Operations, includes communications, the Nimbus Technical Control Center and Space Operations Control Center activities, and orbital computing and acquisition predictions. Part V, Field Station Operations, describes tracking, data-acquisition, Nimbus Data-Handling Systems operations, and Weather Bureau meteorological team activities at the field stations. Part VI describes Automatic Picture Transmission station operations related to the Nimbus program. Part VII outlines the Weather Bureau's plan for data processing and archiving; Part VIII is the GSFC plan for the HRIR experiment.

Appendix A is a detailed description of the spacecraft, vehicle, and a list of aerospace ground equipment; Appendix B is a list of abbreviations; the GSFC Public Information Office plan for support of Nimbus is outlined in Appendix C.

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PART I

PROJECT SUMMARY

This summary describes the objectives, introduces each element of the Nimbus program, and gives a brief description of its operation; details of operation are found in subsequent parts of the plan.

1. NIMBUS PROJECT OBJECTIVES

The Nimbus project was established in August 1959 as a research and development (R&D) program within the Aeronomy and Meteorology (A&M) Division of Goddard Space Flight Center (GSFC) at Greenbelt, Md. Major contracts were awarded in 1961. The Nimbus spacecraft, named after the Latin word for cloud formation, is a second-generation spacecraft that evolved directly from the Television Infrared Observation Satellite (TIROS) program. The Nimbus family of spacecraft will provide:

- A series of large, amply powered earth-stabilized omnibus spacecraft for meteorological research and development
- A near-polar orbit for daily global observation of weather systems
- Tests of a large variety of sensors for atmospheric research and operational application
- Meteorological data for research and for immediate operational use
- A system to acquire and process the atmospheric data in real time

2. ELEMENTS OF THE NIMBUS SYSTEM

The major elements of the Nimbus system (Figure I-1) are:

- A launch vehicle that will place the spacecraft into the precise orbit required
- A spacecraft of widely expanding capability for observing the atmosphere and for rapid transmission of the collected data

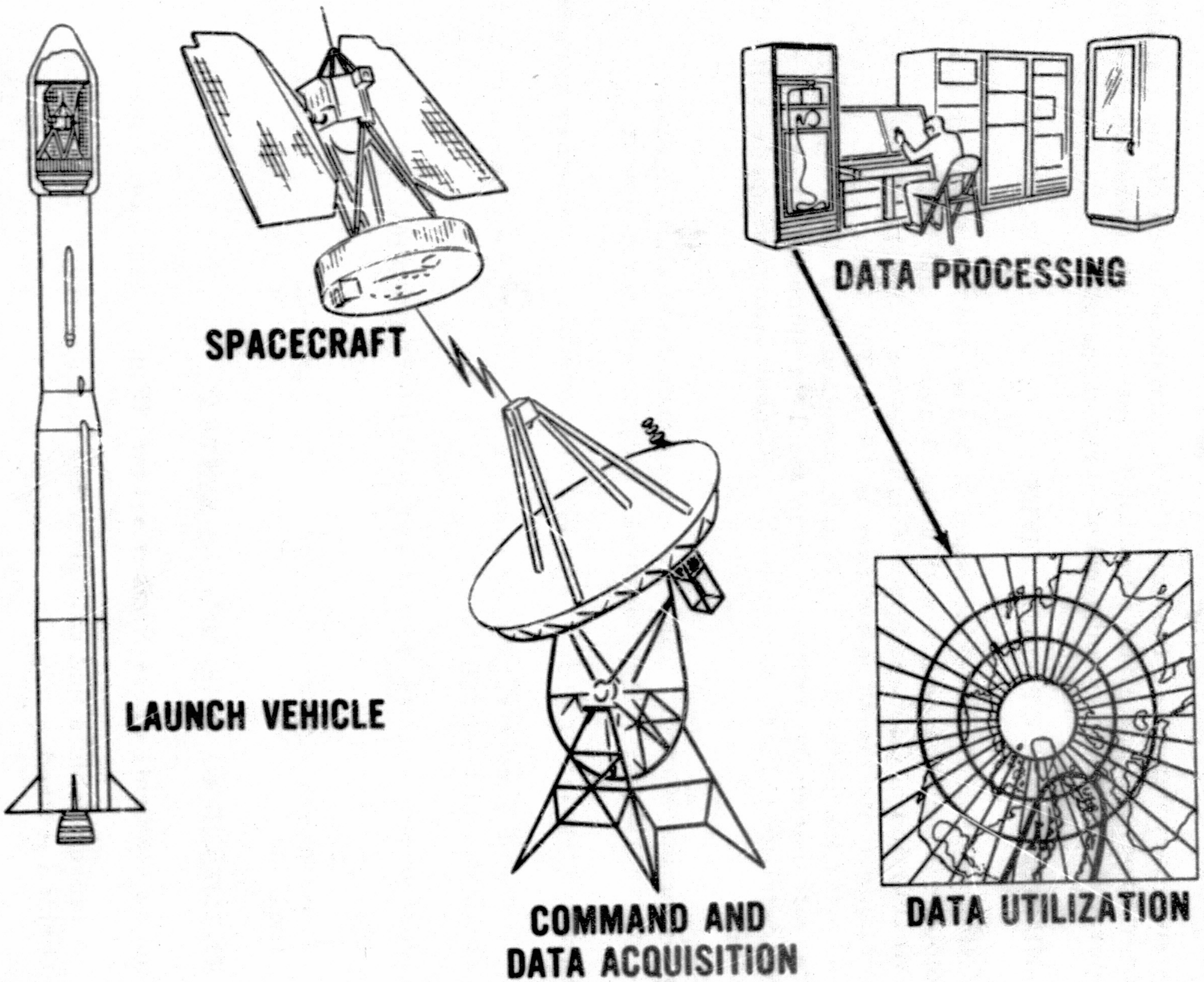

Figure I-1 – Elements of the Nimbus System

- A ground command and data-acquisition system that will control the spacecraft in orbit and receive engineering and meteorological data from the satellite

- A ground data-handling and transmission system that will provide the users with the necessary information in convenient form and in the appropriate time scale

The first R&D spacecraft, Nimbus A, will be launched from the Pacific Missile Range (PMR) in the third quarter of 1964. It will be in a circular near-polar orbit at an altitude of 500 nautical miles with an orbital period of 103 minutes. The near-polar orbit will provide latitudinal coverage, and the rotation of the earth will provide longitudinal coverage over successive orbits. The launch will occur about midnight in order to achieve a "high-noon" orbit—the spacecraft will view the earth at near local noon on the sunlight side and near midnight on the dark side. Nimbus A, weighing approximately 800 pounds, will be earth-oriented at an inclination of approximately 81 degrees retrograde with respect to the equator and stabilized at ± 1 degree. Its orbital plane will precess at a rate equal to that of the earth's rotation around the sun and will always include the earth-sun line. The satellite lifetime is expected to be about 6 months.

A three-camera advanced vidicon subsystem (AVCS) will photograph cloud-cover data on the day side of the Nimbus orbit (Figure I-2) and a high-resolution infrared radiometer (HRIR) will provide cloud-cover data during the dark portion of the orbit (Figure I-3). These data will be stored on magnetic tape recorders in the spacecraft and played back upon command from two ground stations. A pulse-code-modulated (PCM) telemetry system will transmit stored and real-time engineering "housekeeping" information. An additional wide-angle television camera will provide automatic picture transmission (APT) of cloud-cover pictures on a real-time basis for local weather forecasting (Figure I-4).

Data-acquisition facility (DAF) stations in Gilmore Creek, Alaska (GILMOR), and Rosman, N. C. (ROSMAN), will command the satellite and acquire engineering and meteorological data. These two DAF stations are part of the Space Tracking and Data-Acquisition Network (STADAN) operated by GSFC. The data acquired at GILMOR will be processed at the station by a Nimbus Data-Handling System (NDHS) and relayed by the NASA communications (NASCOM) system to the Nimbus Technical Control Center (NTCC) at GSFC. Raw data will be relayed via microwave from the ROSMAN station to an NDHS facility

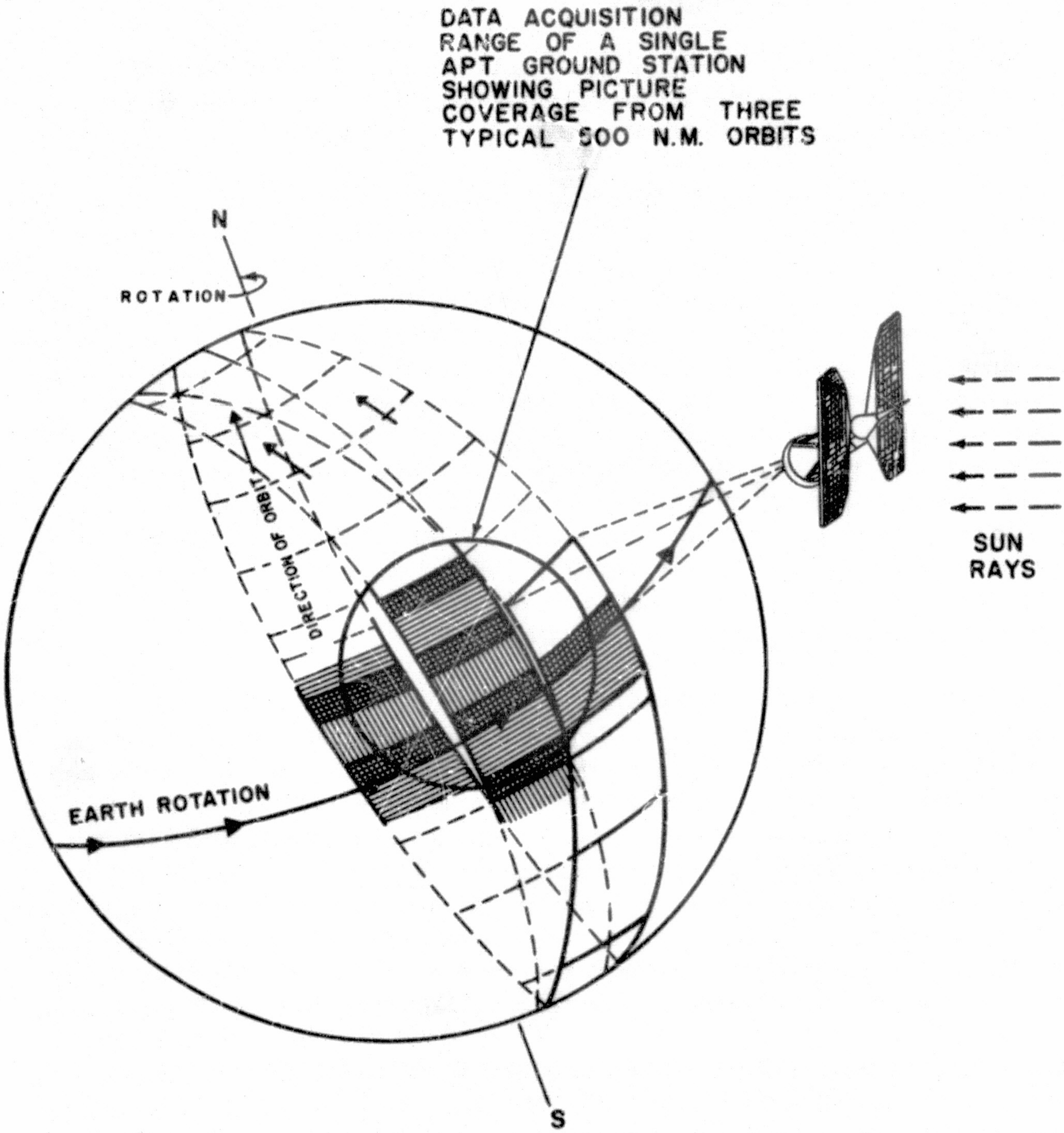

Figure I-2 – Advanced Vidicon Camera Subsystem (AVCS) Coverage

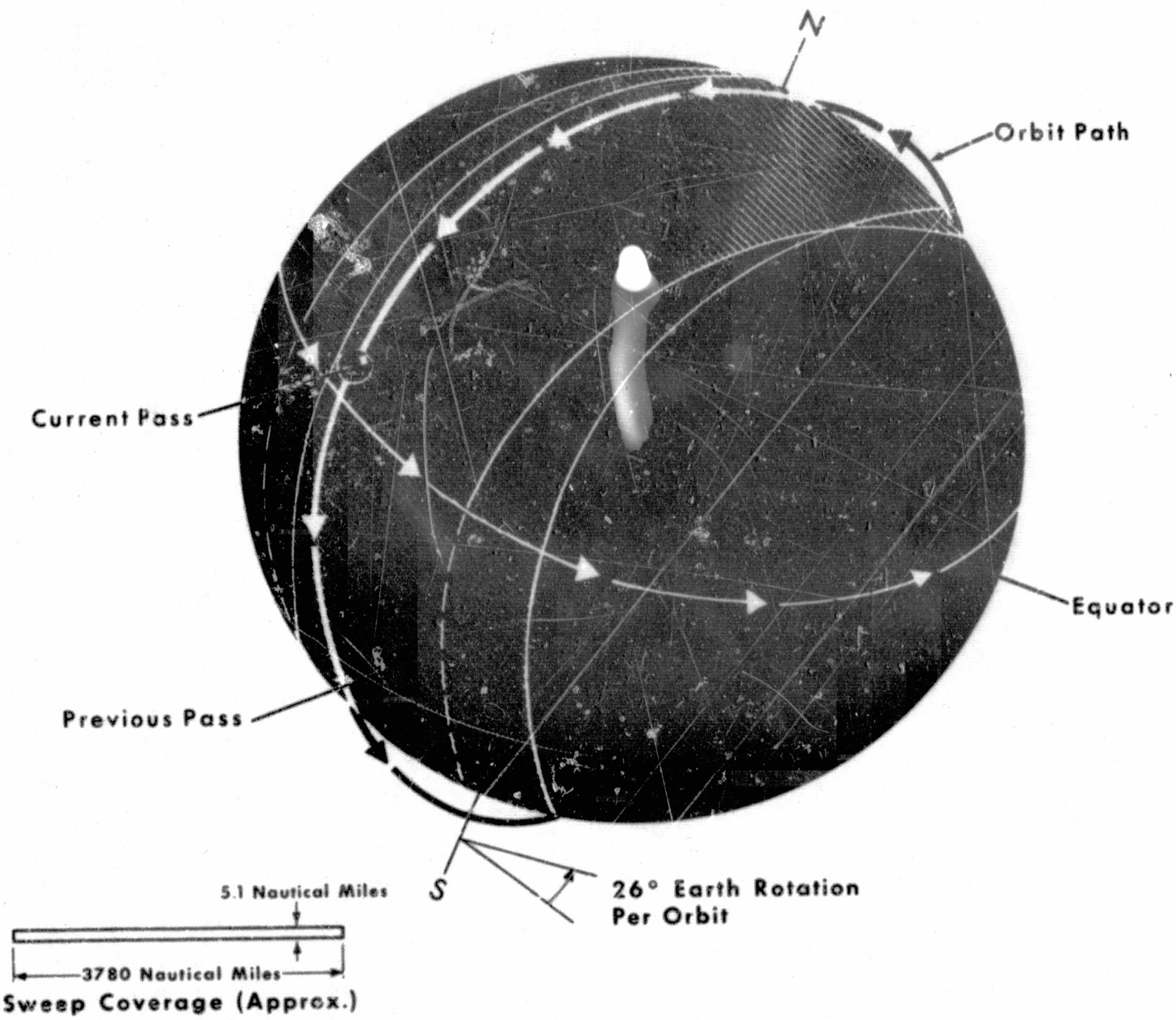

Figure I-3 – High-Resolution Infrared Radiometer (HRIR) Coverage

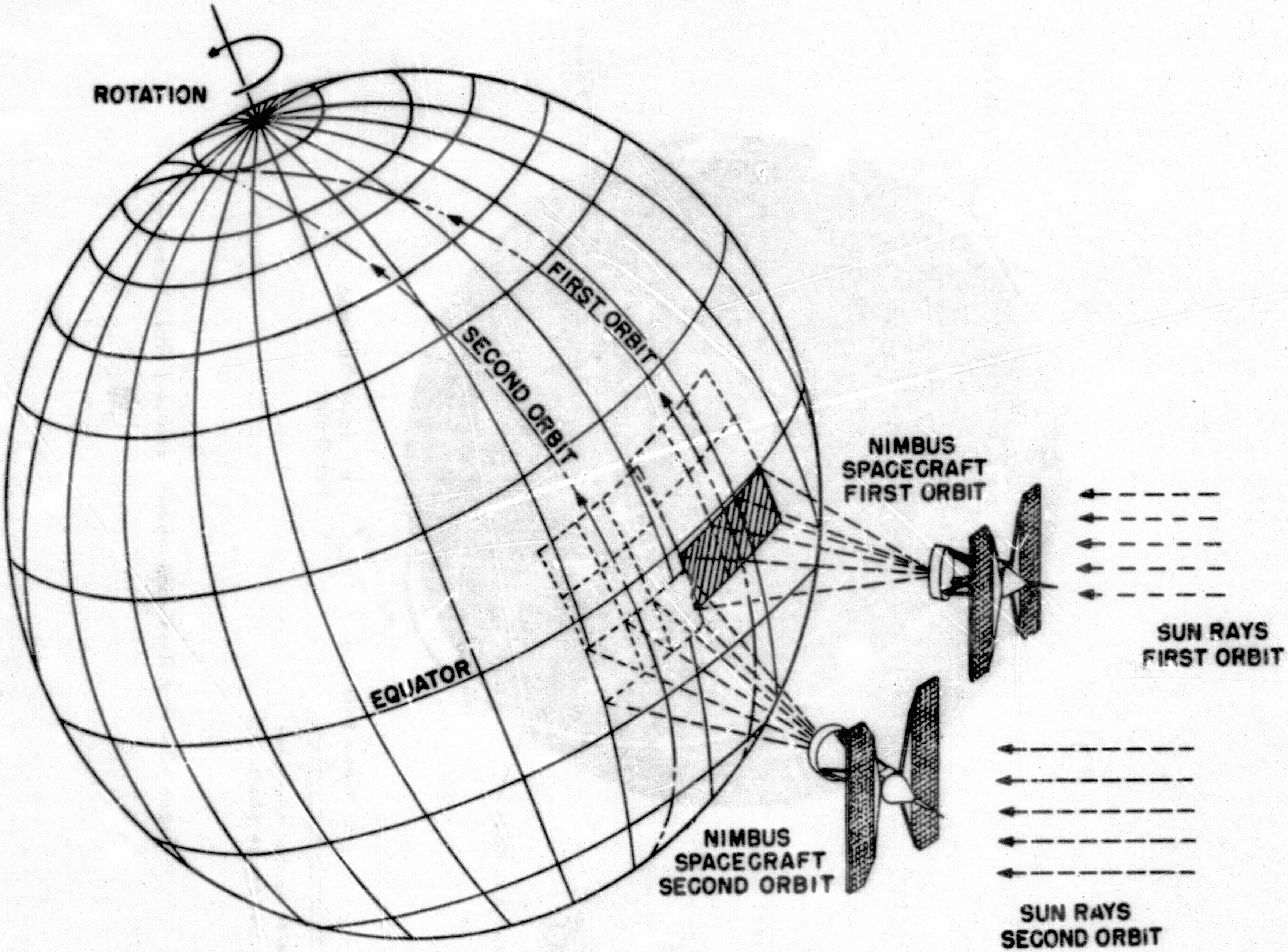

Figure I-4 – Automatic Picture-Transmission (APT) Coverage

at GSFC. The STADAN stations will track the spacecraft. Tracking data will be used at GSFC to determine the orbit and to compute orbital predictions, which will be sent to the STADAN stations. The U. S. Weather Bureau's National Weather Satellite Center (NWSC) will analyze, disseminate, and archive the cloud data used for operational meteorological purposes. Data flow is shown in Figure I-5.

A brief description of each of the system elements follows.

3. LAUNCH VEHICLE

The Nimbus A spacecraft will be launched by a Thor-Agena B vehicle (Figure I-6). The Thor booster is a Douglas DM-21, Mod. II, which uses liquid oxygen and RJ-1 in a Rocketdyne engine. Two Rocketdyne vernier engines are used for final adjustment and roll control. The Agena B, manufactured by Lockheed, uses unsymmetrical-dimethylhydrazine (UDMH) as fuel and inhibited red fuming nitric acid (IRFNA) as the oxydizer. The Agena is attached to the Thor by an adapter which stays with the Thor at separation. The adapter contains the Thor retrorockets and the Agena destruct system. The destruct mechanism is activated upon malfunction of the separation mechanism or upon ground command before separation.

4. SPACECRAFT

The R&D developments for Nimbus A include the use of closed-loop control in three axes to achieve a stabilized platform; improvements in range, resolution, and linearity in the camera system, resulting in increased coverage and more useful pictures; nighttime cloud pictures; and the use of digitized HRIR in the ground station.

The Nimbus spacecraft (Figure I-7) has three major elements: an upper hexagonal attitude control housing, a lower sensory ring, and two solar paddles. The control housing is attached to the sensory ring by means of a truss structure.

The control housing contains the attitude-control subsystems and provides unobstructed exposed mounting for the sun sensors, horizon scanners, control nozzles, and command antenna. Pneumatically activated shutters located on two sides of the housing maintain the control housing within narrow temperature limits.

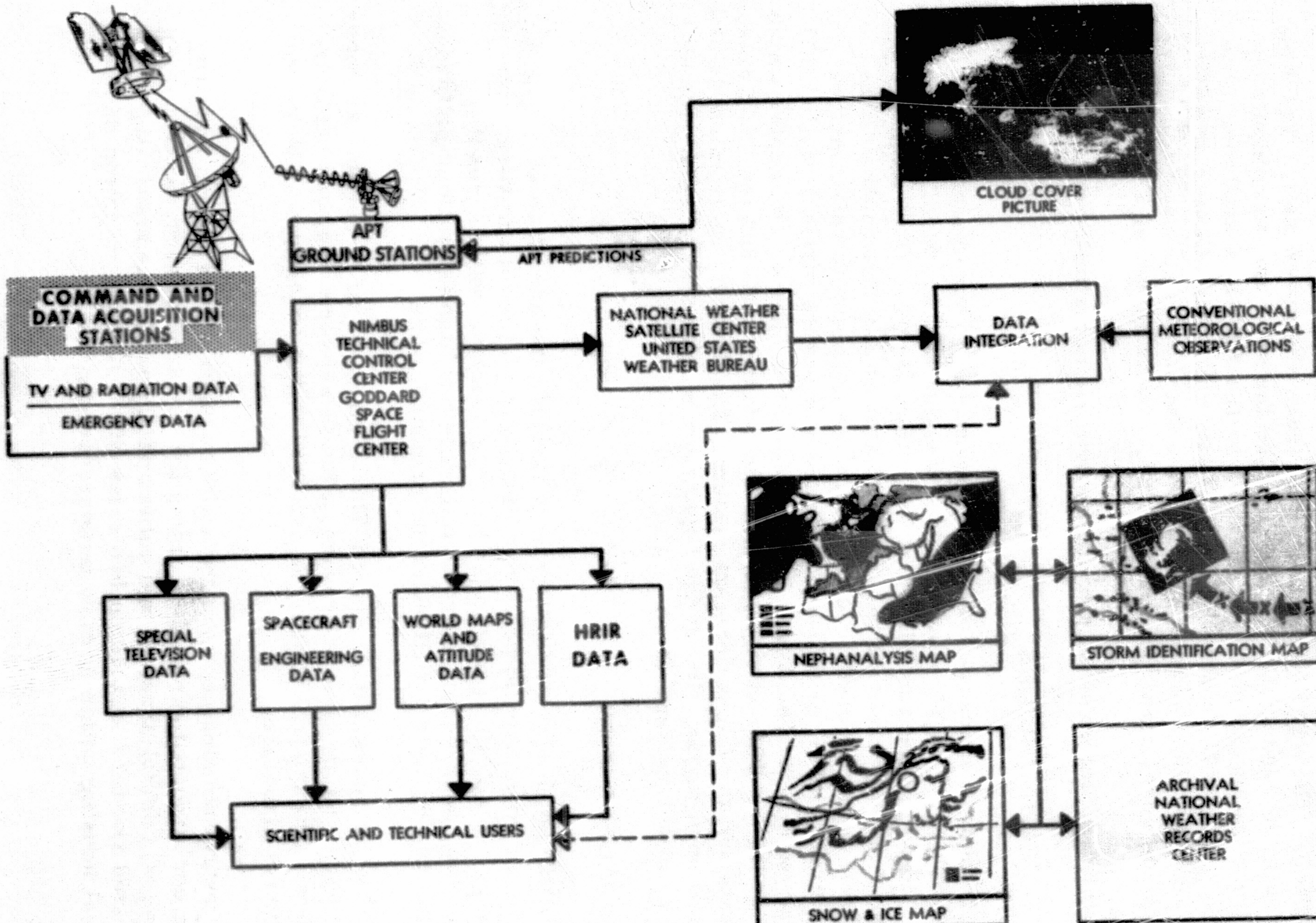

Figure I-5 – Nimbus Program Data Flow

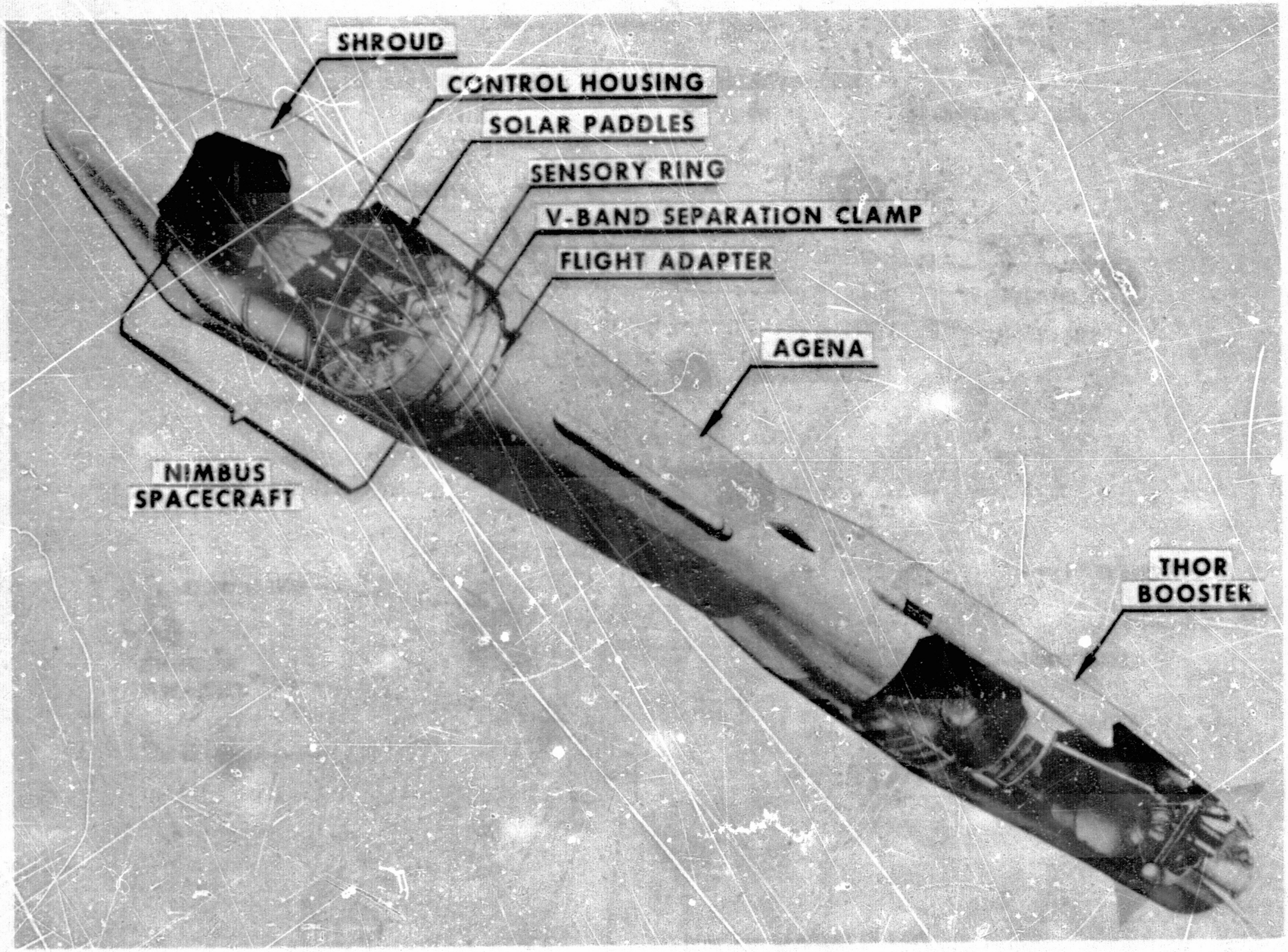

Figure I-6 – Thor-Agena B-Nimbus Launch Configuration

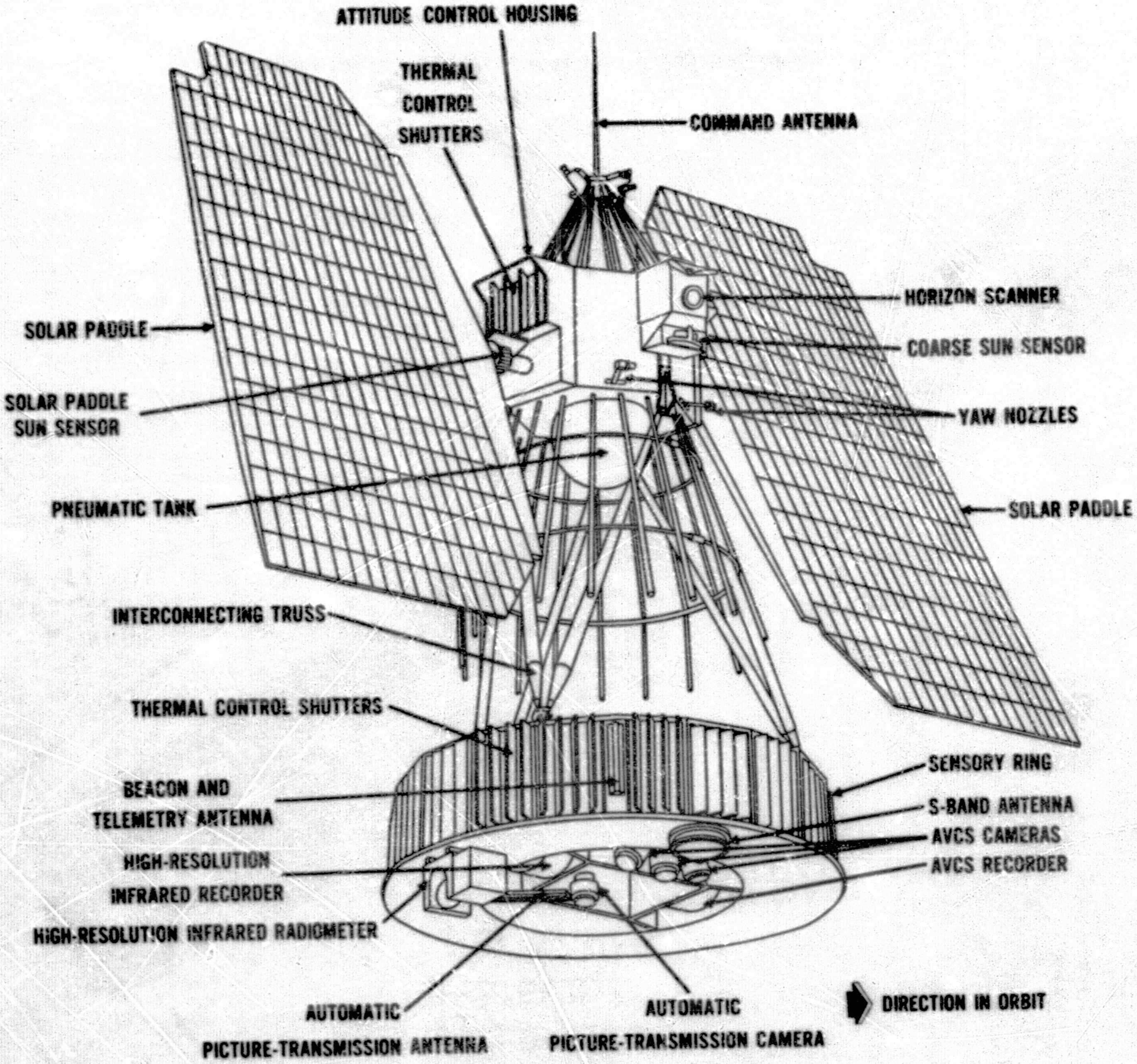

Figure I-7 – Nimbus A Spacecraft

The sensory ring is composed of 18 rectangular module compartments and V-shaped separators. Each compartment is divided horizontally into an upper section and a lower section, which contain the solid-state modularized subsystems and assemblies. The compartments are further divided vertically into quarters to permit greater flexibility of component location.

Pneumatically activated shutters located on the outer diameter of the ring provide separate radiant cooling for each module, thus maintaining an isothermal sensory ring temperature of $25^{\circ} \pm 10^{\circ}C$. An H-frame attached to the inner wall of the ring provides mounting for three advanced vidicon camera system (AVCS) cameras, an automatic picture-transmission (APT) camera, two magnetic tape recorders, and an APT antenna. An S-band antenna and high-resolution infrared radiometer (HRIR) are located on the bottom of the sensory ring and four beacon and telemetry antennas are equally spaced around the outside of the ring.

The solar paddles, which provide power to the spacecraft during the daylight portion of the orbit, attach to shafts projecting from the control housing. The array of solar cells is mounted on two aluminum paddles which rotate to face the sun during daylight. The paddles are constructed to minimize the temperature of solar cell operation.

4.1 POWER SUPPLY SUBSYSTEM

Power is obtained from the sun by two 8- by 3-foot solar paddles connected to the shaft of the control system; the power is transmitted through sliprings to the subassemblies of the spacecraft. Initial power output during periods of full solar illumination is 450 watts.

The solar array also provides a recharge for seven storage batteries located within the sensory ring; the batteries provide power for nighttime operation.

4.2 CLOCK AND COMMAND SUBSYSTEM

The command clock in the spacecraft is the final stage in the command link. It also provides precision frequency outputs and serves as the spacecraft clock. A crystal-stabilized oscillator provides absolute time determination to relate the orbital location of the spacecraft to its geographical location. An 800-kc aged crystal, sealed in glass and maintained at a constant temperature by a heating coil, provides accurate timing reference. The Nimbus spacecraft receives command signals from the data-acquisition facility (DAF) ground stations by

means of the antenna located on the top of the upper housing of the spacecraft. The command receivers reproduce the code generated by the DAF stations and send the code to the command clock. The coded command system controls AVCS/HRIR record and playback, on-off control of experiments, interrogation for stored data, and beacon-transmitter selection.

4.3 ATTITUDE CONTROL SUBSYSTEM

The Nimbus spacecraft must be controlled in three axes to view the earth continuously from a vertical attitude. The attitude control system is housed in a hexagonal unit. Initial stabilization in pitch and roll (after Agena/spacecraft separation) is accomplished by horizon scanner reference, with pitch and roll jets and flywheels. The pitch and roll jets are also used to unload the flywheels should they become saturated. When control in pitch and roll is achieved, yaw reference is established by a yaw gyro operating in a gyro-compassing mode. Yaw control is maintained by a flywheel. If the flywheel becomes saturated, it is unloaded by a gas jet.

4.4 ADVANCED VIDICON CAMERA SUBSYSTEM (AVCS)

The AVCS consists of three television cameras and a tape recorder, all mounted on the H-frame within the sensory ring. Each camera covers a 37-degree field of view. The center camera points straight down at the earth and the others are located at an angle of 35 degrees on either side, giving a 107-degree by 37-degree composite view of the earth in three pictures that overlap by 2 degrees. A sequence timer programs each camera to take a picture every 91 seconds, a total of 30 pictures per orbit. The pictures cover a rectangle 450 nautical miles by 1,450 nautical miles. The output of each camera is fed to a four-track tape recorder which is capable of recording at 30 ips for two complete orbits. Upon station command, the AVCS information is played back at 30 ips via the S-band transmitter. A potentiometer located on the solar-paddle driveshaft switches off the cameras as the sun angle decreases below approximately 85 degrees and turns them on again at 85 degrees above the sun line after the spacecraft comes out of the nighttime phase.

4.5 HIGH-RESOLUTION INFRARED RADIOMETER (HRIR) SUBSYSTEM

The HRIR subsystem consists of an optical system, a photoconductive detector, a mechanical drive, and a tape recorder. The HRIR measures the thermal radiation in the 3.4- to 4.2-micron window region of the atmosphere. The HRIR maps nighttime cloud cover and cloud top

temperature by sensing the apparent differences in radiation intensity as emitted by clouds and the earth's surface. A rotating mirror scans the earth as the satellite advances in orbit. The HRIR has a view angle of 7.8×10^{-3} radian and a 280-cps video bandwidth. It scans 560 elements at 0.83 rps over the 120-degree angle from horizon to horizon. In order to provide a stable, low-noise signal to the electronic amplifier, the infrared radiation is modulated by a mechanical chopper. The HRIR output is recorded and is transmitted via the S-band antenna upon command from the station. A facsimile system reconstitutes the picture at the station.

4.6 AUTOMATIC PICTURE-TRANSMISSION (APT) SUBSYSTEM

The APT subsystem provides real-time pictures for local weather analysis and prediction. The APT spaceborne subsystem consists of a 108-degree wide-angle-lens camera, electronic circuitry, and a transmitter. The camera is located on the bottom of the H-frame; the transmitter is in the sensory ring. The camera photographs an area 1,050 by 1,050 nautical miles. The vidicon surface is prepared during the first 8 seconds. The vidicon is then exposed to the scene for 40 milliseconds. The image is stored electrically on the polystyrene storage layer. During the next 200 seconds, the picture information is readout line by line at a scanning rate of 4 lines per second. A facsimile recorder is synchronized with the scanner to reproduce the picture at the APT ground station.

The APT transmitter sends video information and ground equipment start and synchronization signals. The antenna, mounted on the bottom of the spacecraft, produces a linearily polarized pattern.

4.7 TELEMETRY SUBSYSTEM

The spacecraft has a multimode pulse code modulated (PCM) telemetry system for transmitting information via a transmitter through a phased array antenna to the ground stations. One mode provides stored data by means of an endless-loop tape recorder; another mode provides real-time data on command; a third mode provides a very low rate emergency data readout. The spacecraft time code is placed on the beacon transmitter when telemetry is not being sent.

The S-band transmitter transmits the output of the AVCS and HRIR. The S-band antenna, located on the sensory ring, radiates a circularly polarized wave with a 110-degree beamwidth.

5. GSFC OPERATIONS

All spacecraft, tracking, data-acquisition, and data-handling operations will be controlled from elements within GSFC. Existing communications links will be used, with the focal point at GSFC, to link all field stations with GSFC. The spacecraft's position will be known at all times by computations made at the GSFC Computing Center.

5.1 COMMUNICATIONS

The NASA worldwide communications (NASCOM) system will be used to link the field stations. The wideband (X-108) system to GILMOR will be used for data transfer, the microwave (X-128) system to ROSMAN will be used for real-time commanding and data transfer. The NASA Switching, Conferencing, and Monitoring Arrangement (SCAMA) full period telephone system will provide voice contact with the data-acquisition and command stations, while the teletype network will be used for command messages and communicating with the STADAN stations.

5.2 NIMBUS TECHNICAL CONTROL CENTER (NTCC)

The Nimbus Technical Control Center (NTCC) is established by the Nimbus project at GSFC to provide the Project Manager with the facilities to control and coordinate operational activities of the spacecraft. NTCC has responsibility for evaluation of the spacecraft performance data and the determination of all commands to be transmitted to the spacecraft.

In providing operational control, the NTCC, under the direction of the NTCC Manager, will:

- Prepare all spacecraft command sequences
- Perform continuing analysis of key spacecraft parameters
- Determine corrective action in case of spacecraft subsystem malfunction
- Specify sequence of system data processing
- Evaluate system performance by study of quality of data received

- Monitor and evaluate NDHS ground equipment status and performance

- Schedule NDHS to provide meteorological data to NWSC

5.3 SPACE OPERATIONS CONTROL CENTER (SOCC)

The Space Operations Control Center (SOCC) is established by the GSFC Tracking and Data Systems (T&DS) Directorate to schedule and control the STADAN facilities.

All Nimbus project requirements for the use of the STADAN will be integrated into the NASA master schedule by the Network Controller, (NETCON), using the priority listing established by the Assistant Director, Space Sciences and Satellite Applications, and the Assistant Director, Tracking and Data Systems.

During launch operations, SOCC will control and report on STADAN readiness. Displays will be activated to give SOCC personnel and observers the launch program. After launch, NETCON will:

- Schedule all STADAN stations

- Determine corrective action in case of station malfunction or notify the cognizant Network Engineering and Operations Division personnel if the corrective action is beyond the scope of NETCON

- Disseminate orbital and tracking data

5.4 DATA SYSTEMS DIVISION

The T&DS Data Systems Division will determine the Nimbus orbit; will prepare world maps and tracking and data acquisition station predictions; will compute the solar illumination angle measured at the subsatellite point, the time of sunlight (satellite day) and the time of darkness (satellite night), and the angle between the orbit plane and the earth-sun line. The Data Systems Division will supply predictions by teletype to STADAN.

The Data Systems Division will also prepare the Nimbus APT Daily and Weekly Alert and Ephemeris Prediction messages and send them to USWB for transmittal to the APT stations over the World Meteorological Organization's telecommunications network.

6. FIELD STATION OPERATIONS

Field station operations include tracking, data acquisition, and data processing and handling.

6.1 TRACKING

Tracking operations consist of two phases: trajectory tracking during the launch phase and orbit tracking during the postlaunch phase. Trajectory tracking will be performed by PMR as lead range, supported by the Atlantic Missile Range (AMR). Launch support facilities will perform the initial trajectory tracking functions. Data obtained from the launch tracking network will be transmitted to teletype code GPUT at GSFC in as near real time as possible for use in computing the initial orbit. Orbit tracking will be performed by the STADAN (Figure I-8) stations that are equipped with the 136-Mc to 137-Mc interferometer tracking antennas.

6.2 COMMAND AND DATA ACQUISITION

The Nimbus system will utilize two command and data-acquisition stations. One is located at Gilmore Creek near Fairbanks, Alaska, and the other is at Rosman, N. C. (Figure I-9). These stations are data-acquisition facilities (DAF) of the GSFC-operated STADAN. There are two DAF's at Fairbanks. The ULASKA station is a NASA R&D station built for GSFC missions. The GILMOR station was built to support USWB operational spacecraft. GILMOR will be operated by USWB after a meteorological satellite system becomes operational. The GILMOR station will be used and operated by GSFC for Nimbus A. The ULASKA dish will be used as backup.

GILMOR will acquire the spacecraft an average of 10 of the 14 orbits each day. ROSMAN will acquire an average of 2 orbits a day of the 4 missed at GILMOR and 2 orbits for backup. Both the DAF stations have 85-foot-diameter parabolic antennas to track and command the spacecraft. GILMOR has Nimbus Data-Handling-System (NDHS) equipment to process the data before transmission to GSFC. The ROSMAN station will send the raw data via microwave link to a second set of NDHS equipment at GSFC. A meteorological team at the GILMOR station will examine the sensory data and provide backup analysis in the event of a wideband transmission circuit failure.

6.3 DATA-HANDLING

The meteorological and engineering data transmitted by the Nimbus satellite will be received and processed at the GILMOR DAF station. Selected data from GILMOR will be relayed to NTCC at GSFC over a

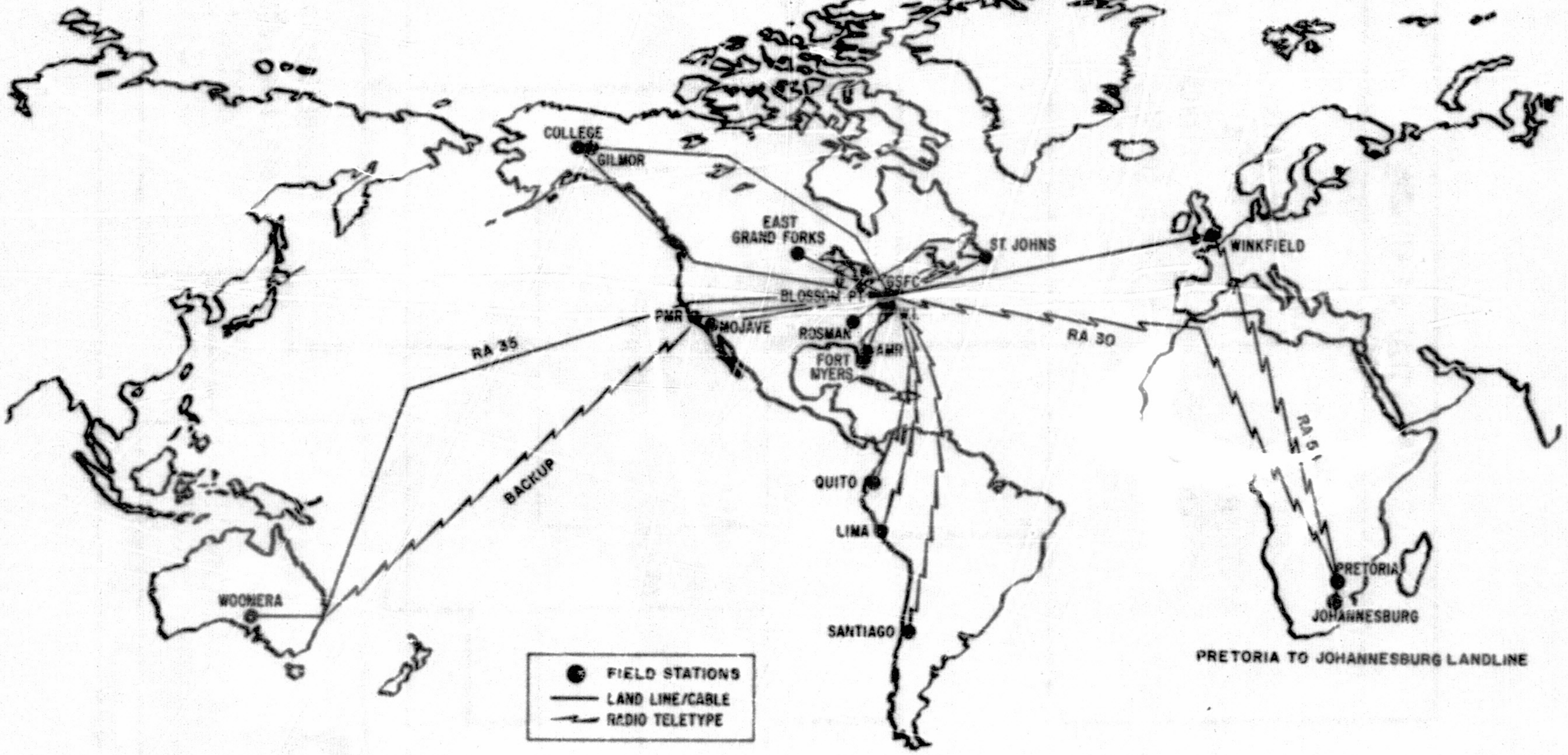

Figure I-8 – Nimbus Launch and Tracking Stations

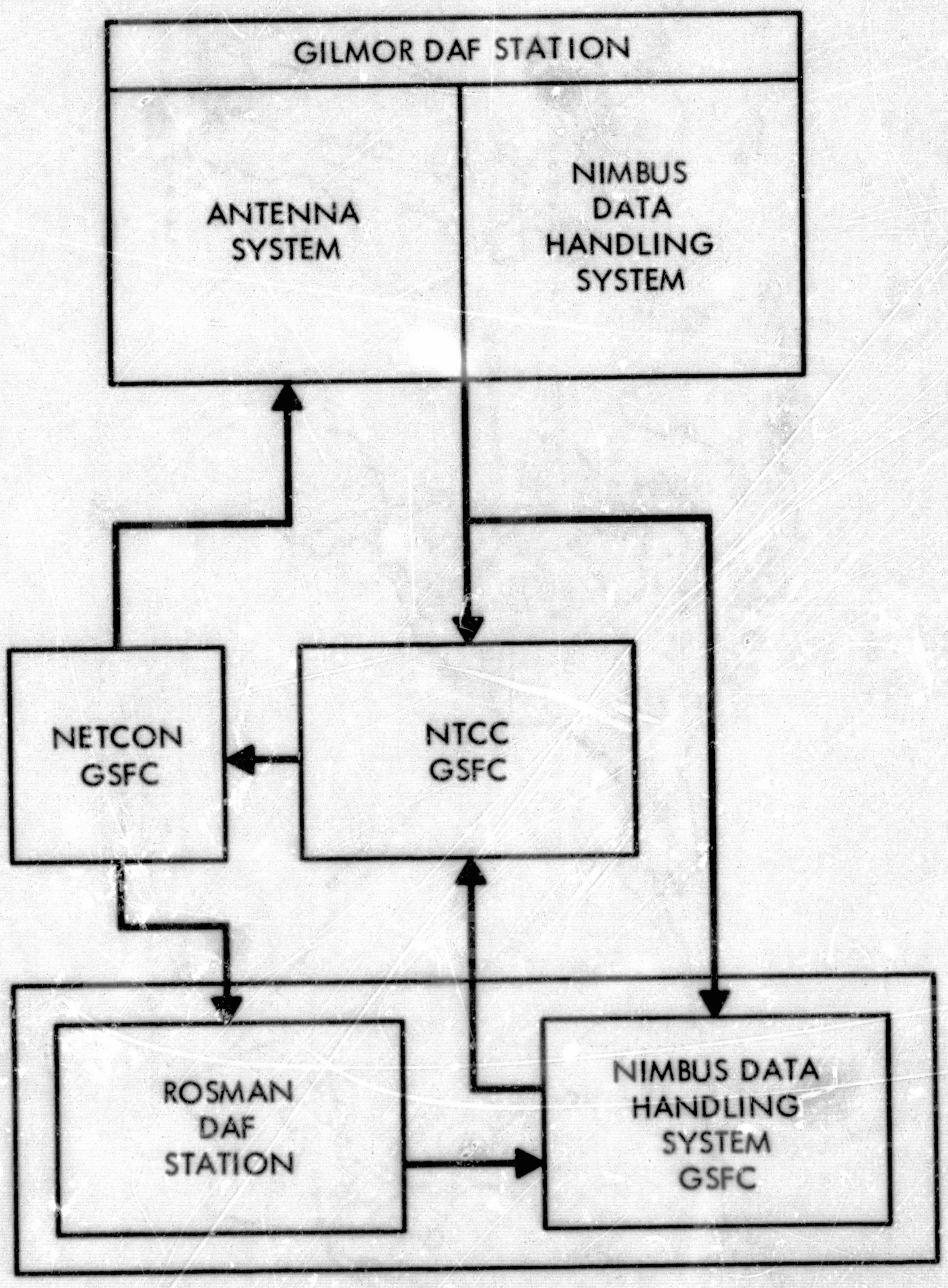

Figure I-9 – Nimbus Command and Data Acquisition

wideband link. NTCC will initiate command programs to be transmitted to the DAF stations over the teletype or wideband link. ROSMAN will receive data from the spacecraft and, in real time, will transmit raw data to the NDHS located at GSFC, where the data will be processed for use (Figure I-9).

The GSFC NDHS, under the direction of the Nimbus NDHS Manager, will:

- Serve as the prime data-handling facility during certain orbits according to schedule, receiving raw data over the 1-Mc data link from ROSMAN

- Provide off-line computer processing support and a means for processing received payload data from a GILMOR pass

- Provide backup data-handling capability in the event of an equipment failure at GILMOR

- Provide an R&D facility for the improvement of the data-handling system

7. APT GROUND STATIONS

APT ground stations produce facsimile photographs for use in local weather analysis and forecasting. APT stations have been built by the Weather Bureau, the U.S. Navy, U.S. Army, U.S. Air Force Air Weather Service, and, under an international program, by many foreign countries. Participation is coordinated by the GSFC A&M Division. Requests for APT programming for each APT station are put into the data programming priority list by the Nimbus Technical Control Center. GSFC prepares APT programming messages and sends them to the Weather Bureau for transmittal over the World Meteorological Organization's (WMO) telecommunications network, in accordance with WMO's manual on codes.

The APT ground stations receive FM signals from the APT spaceborne equipment and reproduce the TV photos on a facsimile recorder. The APT ground system consists of a receiving antenna, cavity filter, preamplifier, FM receiver, and facsimile recorder. Using a very narrow bandwidth for information transmission, the equipment was designed to be simple, inexpensive, and appropriate for wide distribution. In order to acquire the spacecraft and to locate, geographically orient, and grid

the photographs, each APT station is supplied by GSFC with daily and weekly predictive messages and with a kit of working materials.

8. NATIONAL WEATHER SATELLITE CENTER (NWSC)

NWSC will participate in Nimbus data utilization and archiving. NWSC will:

- Provide operational meteorological satellite information to the Weather Bureau, the Department of Defense, other interested United States government agencies, and the world meteorological community

- Archive operational meteorological data from the satellite

- Archive the master film of AVCS pictures and make it available to the meteorological community.

The Data-Processing and Analysis Facility (DAPAF) at NWSC, Suitland, Md., is the central NWSC operating unit that will make use of the Nimbus meteorological data. DAPAF will receive data, will use general and special-purpose computer equipment to locate, format, and digitize the input data and to produce scale-rectified-digital map printouts that will summarize the cloud observations. Gridded TV photographs of the cloud cover will be reproduced by the kinescope equipment.

The final output of DAPAF will include annotated digital computer products; full-resolution, gridded, perspective pictures; graphical nephanalyses; and teleprinted information.

9. HRIR EXPERIMENT

Data from the HRIR experiment will be validated by the A&M Division's Physics Branch and made available to the scientific community. The Physics Branch will also conduct a continuing program of research with HRIR data.

PART II

ORGANIZATION AND DIRECTORY

This part includes GSFC and Nimbus project organization charts and a Nimbus directory. The directory lists individuals and their phone numbers; offices and their phone numbers and mailing addresses; and a cross-reference list of job titles and individuals.

1. INDIVIDUALS

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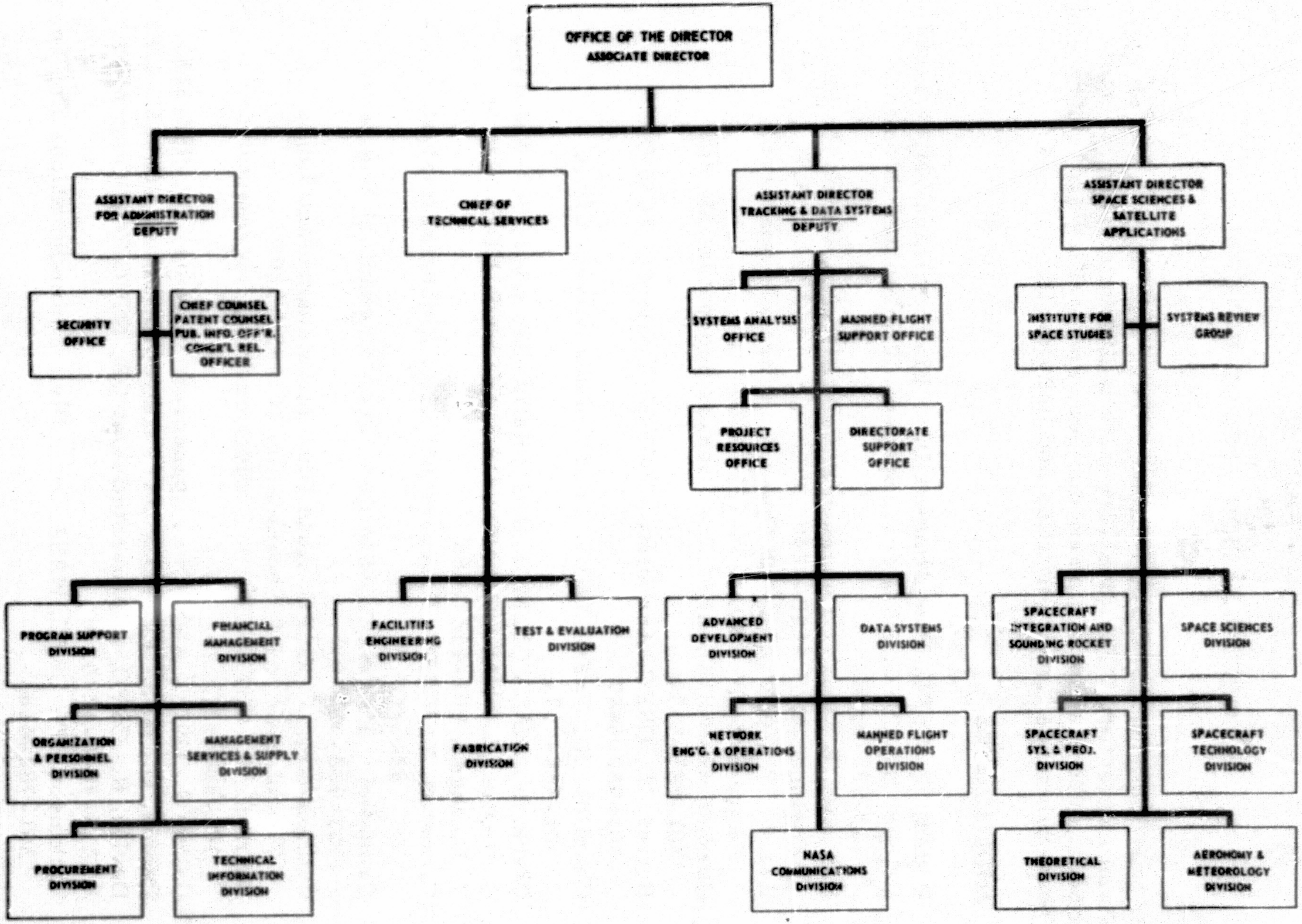


Figure II-1 – GSFC Organization Chart

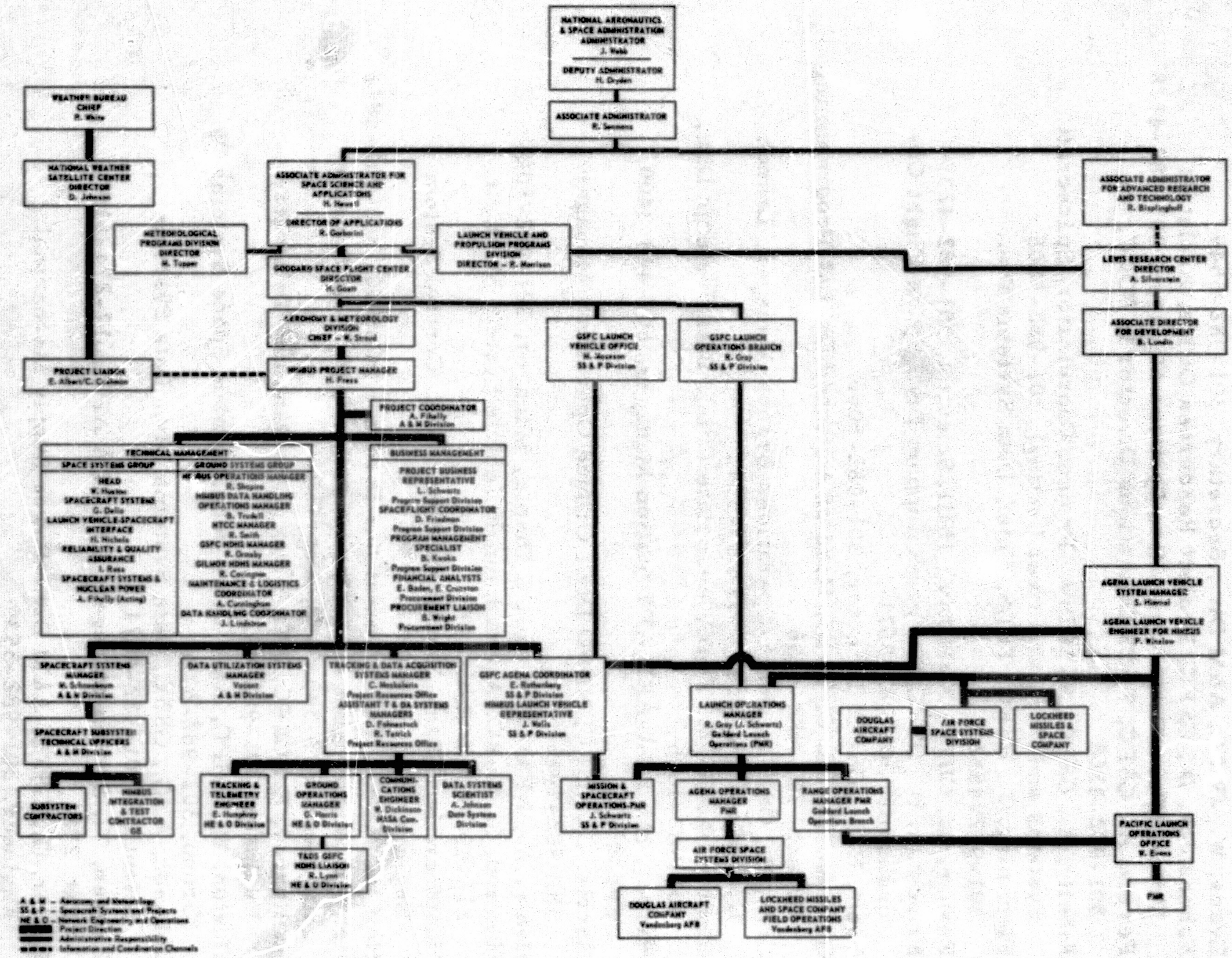


Figure II-2 – Nimbus Project Organization Chart

Drummond, R., GSFC, A&M Div., Launch Operations TO, 301-982-5539

Evans, W., GSFC, A&M Div., Secretary, 301-982-5549

Fahnestock, D., GSFC, Project Resources Office, Assistant Tracking and Data-Acquisition Systems Manager, 301-982-4878

Ferris, A., GSFC, T&DS Operations Director in SOCC, 301-982-4168

Fihelly, A., GSFC, A&M Div., Project Coordinator, Spacecraft Systems and Nuclear Power (Acting), 301-982-5805

Flemming, J., GSFC, T&DS, Chief, Data Systems Div., 301-982-4652

Foshee, L., GSFC, A&M Div., HRIR Scientist, 301-982-4235

Friedman, D., GSFC, Program Support Div., Space Flight Coordinator, 301-982-5671

Goett, H. J., GSFC, Director, 301-982-5066

Gorman, T., GSFC, T&DS, Head of Advanced Orbital Programming Branch, 301-982-4636

Gray, R., GSFC, Launch Operations Branch Manager, Launch Operations Manager, 305-853-5342

Gridley, D., GSFC, T&DS, Associate Chief, Data Systems Div., 301-982-4655

Harper, M., RCA-AED APT Station Manager, 609-448-3400, Ext. 2328

Harris, G., GSFC, NE&O Div., Ground Operations Manager, 301-982-4946

Healy, W., NE&O Div., SOCC Display Manager, 301-982-5046

Himmel, S., LeRC, Agena Launch Vehicle System Manager, 216-433-4000, Ext. 730

Hoepfner, K., GSFC, Representative at GE, Control System Engineer, 215-969-4240

Hoff, H., GSFC, T&DS Operations Director in SOCC, 301-982-4871

Hooper, W., Douglas Aircraft Company, Head Thor Systems Engineer, 213-399-9318, Ext. 7694

Humphrey, E., GSFC, NE&O Div., Tracking and Telemetry Engineer, 301-982-4935

Huston, W., GSFC, A&M Div., Head, Nimbus Space Systems Group, 301-982-5796

Johnson, A. G., GSFC, Data Systems Div., Data Systems Scientist, 301-982-4674

Keegan, T., Station Manager, AFCRLA APT, 617-274-6100, Ext. 2981

Keller, G., GSFC, A&M Div., Power Supply Mechanical Engineer, 301-982-5539

Kohout, J., GSFC, T&DS, Head, Minitrack Section, 301-982-5027

Kwoka, B., GSFC, Programs Support Div., Program Management Specialist, 301-982-5984

Leary, J., GSFC, Representative at GE, All Systems Test Engineer, 215-969-4240

Lee, R., GSFC, Data Systems Div., Data Systems Engineer, 301-982-4527

Lindstrom, J., GSFC, A&M Div., Data Handling Coordinator, 301-982-5337

Lovelace, J., GSFC, A&M Div., Thermal Engineer, 301-982-5978

Lundstedt, C., Station Manager, Wallops APT, 824-3411-208

Lynch, J., GSFC, Meteorological Satellites Public Information Officer, 301-982-4955

Lynn, R., GSFC, NE&O Div., T&DS GSFC NDHS Liaison, 301-982-4946

MacKenzie, C., GSFC, A&M Div., Power Supply System TO, 301-982-5806

Maskaleris, C., GSFC, Project Resources Office, Tracking and Data-Acquisition Systems Manager, 301-982-4878

Meehan, J., GSFC, Representative at GE, Ground Station Operation and Maintenance Coordinator, 215-969-4240

Mengel, J., GSFC, Assistant Director T&DS, 301-982-4765

Mentges, C., GSFC, T&DS, Head, Computer Services Section, 301-982-4923

Miller, B., GSFC, A&M Div., RF Operations Coordinator, 301-982-5737

Nichols, H., GSFC, A&M Div., Launch Vehicle Interface Engineer, 301-982-5805

Nordberg, W., GSFC, A&M Div., HRIR Experimenter, 301-982-5003

Ormsby, R., GSFC, A&M Div., GSFC NDHS Station Manager, 301-982-5268

Over, J., GSFC, A&M Div., Command System TO, 301-982-5737

Press, H., GSFC, Project Manager, A&M Div., 301-982-5549; Mission Director at PMR, 805-734-4311, Ext. 217

Quirey, E., NE&O Div., Network Controller, 301-982-4938

Rayburn, L., Douglas Aircraft Company, Deputy Director of Product Development for Space Programs, 918-836-1616, Ext. 684

Richardson, B., GSFC, T&DS, Head, Orbit Determination Section, 301-982-5623

Risley, W., GSFC, Station Manager, GSFC APT; APT Ground Station Manager at PMR, 301-982-5422

Ross, I., GSFC, A&M Div., Reliability and Quality Assurance, 301-982-4117

Rothenberg, E., GSFC, Spacecraft Systems and Project Div., GSFC Agena Coordinator, 301-982-4333

Sargent, J., GSFC, A&M Div., Control Systems TO, 301-982-5850

Schlachman, B., GSFC, A&M Div., PCM System TO, 301-982-5672

Schneebaum, M., GSFC, A&M Div., Spacecraft Systems Manager, 301-982-5736

Schwalb, A., NWSC, Station Manager, USWB APT, 301-735-2000, Ext. 7148

Schwartz, J., GSFC, Launch Operations Branch, Associate Manager, PMR, Launch Operations Manager, NASA Test Director at PMR, 805-734-4311, Ext. 21

Schwartz, L., GSFC, Program Support Div., Project Business Representative, 301-982-5337

Shapiro, R., GSFC, A&M Div., Nimbus Operations Manager, 301-982-4117

Shoenhair, J., Lockheed Missiles and Space Company, Director, Medium Space Vehicle Programs, 408-739-4321, Ext. 21605

Siry, J., GSFC, T&DS, Head, Theory and Analysis Office, 301-982-4905

Smith, E., GE, Spacecraft Test Conductor, 215-969-4240

Smith, R., GSFC, A&M Div., NTCC Manager, 301-982-4510

Stengard, E., GSFC, A&M Div., Mechanical Systems Engineer, 301-982-5850

Strong, J., Jr., GSFC, A&M Div., Senior Spacecraft Engineer, 301-982-5868

Stroud, W. G., GSFC, Chief, A&M Div., Mission Representative at PMR, 301-982-4400

Tepper, M., NASA Hq., Director, Meteorological Programs, 301-963-6521

Tetrick, H., GSFC, Project Resources Office, Assistant Tracking and Data-Acquisition Systems Manager, 301-982-4878

Thienel, C., GSFC, A&M Div., Pneumatics Engineer, 301-982-5819

Townsend, J. W., GSFC, Assistant Director, Space Science and Satellite Applications, Project Liaison Officer in SOCC, 301-982-5121

Trudell, B., GSFC, A&M Div., Nimbus Data Handling Operations Manager, 301-982-4117

Walls, J., GSFC, Spacecraft Systems and Projects Div., Nimbus Launch Vehicle Representative, 301-982-4313

Weiland, S., Spacecraft Systems Test Director, 301-982-5818

Weir, J., GLO, Spacecraft Launch Conductor, 805-734-4311, Ext. 21

Winslow, P., LeRC, Agena Launch Vehicle Engineer for Nimbus, 216-433-4000, Ext. 730

Wright, B., GSFC, Procurement Div., Procurement Liaison, 301-982-5796

2. TITLES

Titles listed here are cross-referenced to the list of individuals in 1, above. The location listed after each title indicates where the person will be during launch operations.

Agena Launch Conductor (Blockhouse), (unassigned) (LMSC)
Agena Launch Vehicle Engineer for Nimbus (MDC), P. Winslow
All Systems Test Engineer (NSCC), J. Leary
APT Coordinator (GSFC), A. Cunningham
APT Ground Station Manager, PMR (NSCC), W. Risley
APT Station Managers, see M. Clark, T. Keegan, M. Harper, W. Risley, A. Schwalb, C. Lundstedt
Center Displays Controller (MDC), (GLO - unassigned)
Command System TO (GSFC), J. Over
Communications Controller (SOCC), (T&DS - unassigned)
Communications Engineer (SOCC), W. Dickinson
Control System Engineer (GSFC), K. Hoepfner
Control System TO (NSCC), J. Sargent
Data Coordinator (MDC), (GLO - unassigned)
Data Handling Coordinator (GSFC), J. Lindstrom
Data Systems Engineer (NSCC), R. Lee
Data Systems Scientist (GSFC), A. Johnson
Data-Utilization Systems Manager (GSFC), (vacant)
Display Manager (SOCC), W. Healy
Ground Operations Manager (SOCC), G. Harris
Ground Station Operation and Maintenance Coordinator (NSCC), J. Meehan
GSFC Communicator (MDC), (unassigned)
HRIR Experimenter (GSFC), W. Nordberg
HRIR Scientist (GSFC), L. Foshee
Launch Control Officer (Blockhouse), (AFSSD - unassigned)
Launch Operations Group (S/C Lab-NSCC), Head, W. Huston (MDC) See Figure III-5
Launch Operations Manager (MDC), R. Gray/J. Schwartz
Launch Operations TO (NSCC), R. Drummond
Launch Vehicle Interface Engineer (NSCC), H. Nichols
Launch Vehicle System Manager, Agena, (MDC), S. Himmel
Launch Vehicle Representative, Nimbus, (RUB), J. Walls
Lead Mechanical Engineer (NSCC), P. Crossfield
Mechanical Systems Engineer (NSCC), E. Stengard
Meteorological Programs Division Representative, NASA Hq. (MDC (unassigned)

Mission Director (MDC), H. Press
Mission Representative (Blockhouse), W. Stroud
NASA Console Operators (Blockhouse), (unassigned)
NASA Test Director (Blockhouse), J. Schwartz
NDHS Manager, R. Ormsby, GSFC, L. Covington, GILMOR; T&DS GSFC NDHS Liaison, R. Lynn
Network Controller (SOCC), E. Quirey
Nimbus Data Operations Manager (GSFC NDHS), B. Trudell
Nimbus Operations Manager (GILMOR NDHS), R. Shapiro
NSCC Test Controller (NSCC), R. Devlin
NTCC Manager (NTCC), R. Smith
PMR Representative (MDC), (unassigned)
Power Supply Mechanical Engineer (NSCC), G. Keller
Power Supply System TO (NSCC), C. MacKenzie
Pneumatics Engineer (NSCC), C. Thienel
Project Coordinator (GSFC), A. Fihelly
Project Liaison Officer (SOCC), J. Townsend
Project Manager (MDC), H. Press
Public Information Officer (RUB), J. Lynch
Range Safety Officer, AFSSD Representative (Range Operations Building), (unassigned)
RF Operations Coordinator (NSCC), B. Miller
Senior Spacecraft Engineer (Blockhouse), J. Strong
Sensor Subsystem Monitor (NSCC), G. Burdett
Spacecraft Handling Engineer (NSCC), R. Berkwitt
Spacecraft Launch Conductor (Blockhouse), J. Weir
Spacecraft Subsystem Monitor (NSCC), D. Beiber
Spacecraft Systems Manager (MDC), M. Schneebaum
Spacecraft Systems Test Director (NSCC), S. Weiland
Spacecraft Test Conductor (S/C Lab-NSCC), E. Smith
SLV-2 Launch Conductor (Blockhouse), DAC - unassigned)
T&DS Operations Director (SOCC), H. Hoff/A. Ferris
Thermal Engineer (NSCC), J. Lovelace
Tracking and Data-Acquisitions Systems Manager (SOCC), C. Maskaleris; Assistant Tracking and Data-Acquisition Systems Managers, D. Fahnestock, H. Tetrick
Tracking and Telemetry Engineer (SOCC), E. Humphrey
WECO Launch Conductor (Blockhouse), (WECO - unassigned)
6595th ATW Representative (MDC), (unassigned)

3. OFFICES

Douglas Aircraft Company, 2000 North Memorial Drive, Tulsa, Okla., 918-836-1616

Douglas Aircraft Company, 3000 Ocean Park Blvd., Santa Monica, Calif., 213-399-9318

General Electric, Valley Forge, Pa., 215-969-4240

GILMOR DAF, Gilmore Rd., Mile 13, Steese Highway, Fairbanks, Alaska, 907-452-1466

Goddard Space Flight Center, Greenbelt, Md., 301-474-9000

Lewis Research Center, 21000 Brookpark Rd., Cleveland 35, Ohio, 216-433-4000

Lockheed Missiles and Space Company, P. O. Box 504, Sunnyvale, Calif., 408-739-4321

National Weather Satellite Center, Suitland, Md., 301-735-2000

NASA Headquarters, 400 Maryland Ave., S.E., Washington 20546, D. C. 301-963-6521

NDHS, GSFC, Greenbelt, Md., 301-982-5268

Nimbus Message Center, PMR, 805-734-4311, Ext. 217

Nimbus Project Office, GSFC, Greenbelt, Md., 301-982-5549

NTCC, GSFC, Greenbelt, Md., 301-982-4510

ROSMAN DAF, P. O. Box 838, Rosman, N. C., 704-862-4282

SOCC, GSFC, Greenbelt, Md., 301-982-5151

4. COMMITTEES

4.1 NIMBUS ENVIRONMENTAL TEST COMMITTEE

The Nimbus Project Manager has established a Nimbus Environmental Test Committee which will advise him as to the acceptance or rejection of the results of the prototype and flight environment tests of the spacecraft. In addition, the committee will periodically review the test program and recommend to the Project Manager changes in the program or test levels that may be dictated by experience or new information. The committee will not be concerned with component and subassembly environmental testing; however, a qualification sheet will be submitted to the committee for each environmentally tested subassembly and subsystem for the prototype and flight model. The committee will also determine the disposition or additional testing of prototype or flight models that fail to qualify under environmental tests.

The Nimbus Environmental Test Committee consists of seven members. A. White, an engineer in the Aeronomy & Meteorology Division, GSFC, is chairman of the committee, and represents the division, together

with P. Crossfield and M. Weinreb. E. DeGraff is the committee secretary and represents the Test and Evaluation Division, GSFC. S. Drabek, GE contractor Project Engineer, is the Mechanical Engineer, and S. Charp, GE, the Electronics Engineer. W. Huston represents the Nimbus project.

4.2 JOINT METEOROLOGICAL SATELLITE ADVISORY COMMITTEE (JMSAC)

The Joint Meteorological Satellite Advisory Committee (JMSAC) meets monthly to discuss problems and the status of programs concerning R&D meteorological satellites. This NASA committee is composed of members from NASA Headquarters, the Department of Defense (DOD), the U. S. Weather Bureau (USWB), and GSFC.

Objectives of JMSAC are:

- To consider the requirements of DOD, USWB, and NASA in the meteorological satellite program
- To serve as a medium for the interchange of information among DOD, USWB, and NASA members
- To assist wherever possible and appropriate in operating programs

5. AGENA PANELS

Technical panels have been established to advise and assist the Agena Launch Vehicle System Manager, Project Managers, and the GSFC Launch Vehicle Projects Office, in the resolution of interface problems concerning the Agena. These panels are composed of representatives from NASA Headquarters, GSFC, Lewis Research Center (LeRC), Air Force Space Systems Division (AFSSD), and Lockheed Missiles and Space Company (LMSC). Representatives from Convair Astronautics Division, Douglas Aircraft Company (DAC), the Atlantic Missile Range (AMR), and the Pacific Missile Range (PMR), attend as required.

5.1 PERFORMANCE, TRAJECTORIES, GUIDANCE AND CONTROL AND FLIGHT DYNAMICS PANEL — K. A. Faymon, LeRC, Acting Chairman

This panel continually reviews, compiles, evaluates, and interchanges data relating to vehicle performance, ascent trajectories, vehicle guidance and control, and flight dynamics as they interact with the

vehicle, shroud, and spacecraft interfaces. The panel is composed of representatives from GSFC, LeRC, LMSC, and DAC with GSFC acting as chairman.

5.2 TRACKING AND DATA-ACQUISITION PANEL — C. L. Maskaleris, GSFC, Chairman

The function of this panel is to review, interchange data, and assess the tracking, telemetry, and communications requirements and range support capability for the Nimbus program. It is the purpose of this panel to pinpoint problems in these areas, determine possible courses of action, and recommend solutions. The panel is composed of representatives from NASA Headquarters, GSFC, LeRC, NASA Pacific Launch Operations Office, AFSSD, PMR, AMR, and LMSC, with GSFC acting as chairman.

6. WORKING GROUPS

6.1 LAUNCH TEST WORKING GROUP (LTWG)

This group acts as the prime mechanism for coordinating flight preparations at PMR. Members of the LTWG participate in mission, spacecraft, vehicle, and range-readiness meetings and in day-to-day preparations for launch. The LTWG includes representatives from 6596th ATW, GSFC Launch Operations Branch, PMR, LMSC, DAC, BTL, and the Nimbus project. This group is chaired by a representative of the 6595th ATW.

6.2 FLIGHT TEST EVALUATION GROUP

The Flight Test Evaluation Group will evaluate the performance of the spacecraft in orbit as compared with the design goals. Members are R. Shapiro, G. Burdett, D. Beiber, C. Bolton, and R. Smith.

PART III

VEHICLE AND SPACECRAFT OPERATIONS

1. GENERAL APPROACH

This part describes the vehicle and spacecraft operations required for Nimbus launch operations at the Pacific Missile Range (PMR). It identifies the organizations and some key personnel responsible, defines the interfaces, and establishes the manner in which the operations will be conducted. For convenience, the operations sections are considered in three phases: prelaunch, launch, and postlaunch. The emphasis is on the spacecraft operations, with enough description of the vehicle operations and communications to show their interrelationships.

See Appendix A for detailed descriptions of the spacecraft, vehicle and ground station vans, and a list of ground equipment required at PMR.

The Nimbus spacecraft operations at PMR focus on two major hardware items: the flight spacecraft and the prototype spacecraft, which is electrically and mechanically equivalent to the flight model. Both spacecraft will be mounted on their adapters, with pyrotechnics and separation systems installed, and will be air-shipped to PMR. The prototype is required at least 27 days before launch, during the time period when the flight spacecraft is completing assembly and qualification. The flight spacecraft will arrive nine days prior to launch; it will not thereafter be removed from the adapter. Its readiness for launch will be established by two means:

- Successful completion of the preflight go/no-go tests, including a high degree of correlation with similar tests performed prior to shipment

- Successful completion of the PMR test program for the prototype

Early arrival of the prototype spacecraft at PMR is designed to permit a more extensive test program involving a check of all sensor calibrations and oriented toward verification that a qualified Nimbus can be air-shipped to PMR without compromise of its flight readiness. In addition, the prototype will participate in the mock countdown and will be used in all later tests planned for the flight spacecraft. This use of

the prototype will assure qualification of the hardware, the procedures, and the people involved in the launch operation.

2. PACIFIC MISSILE RANGE ORGANIZATION AND FACILITIES

PMR is one of the two national ranges which provide launch, tracking, and telemetry support for NASA missions under the interagency agreements providing for this support from the Department of Defense (DOD). The launch operations site for Nimbus is Pad 75-1-1, a part of the Vandenberg Air Force Base (VAFB) complex; most of the tracking and telemetry facilities are provided at Point Arguello (NMFPA) and San Nicolas Island. (During the period of Nimbus launch operations at PMR, the Air Force will assume jurisdiction of the facilities at NMFPA). A map of the area showing the principal facilities associated with the Nimbus launch is shown in Figure III-1. Special attention is drawn to the following:

- The main gate, Point Arguello, which is the point of entry for all government and contractor personnel associated with the Nimbus project
- The Range Users Building (RUB) (Figure III-2), headquarters of the NASA GSFC Launch Operations Branch (GLO), Langley Research Center Field Projects Office, the Pacific Launch Operations Office (PLOO), and the GSFC Mission Director Center (MDC)
- The GLO Spacecraft Laboratory and Telemetry Station (S/C Lab) (Figure III-3), principal center for all spacecraft activities and location of the Nimbus Spacecraft Control Center (NSCC)
- The Lockheed and Douglas Missile Assembly Buildings (MAB), the centers of Agena and Thor checkout activities, respectively
- Pad 75-1-1 (Figure III-4), location of the NASA gantry and the Control Center (CC-1) blockhouse, site of the Nimbus launch
- The Southern Pacific Railroad, a heavily travelled rail-line which passes through the entire complex and provides a major perturbation in planning the liftoff time of PMR launches
- Communications network used by Nimbus at PMR (Figure III-5)

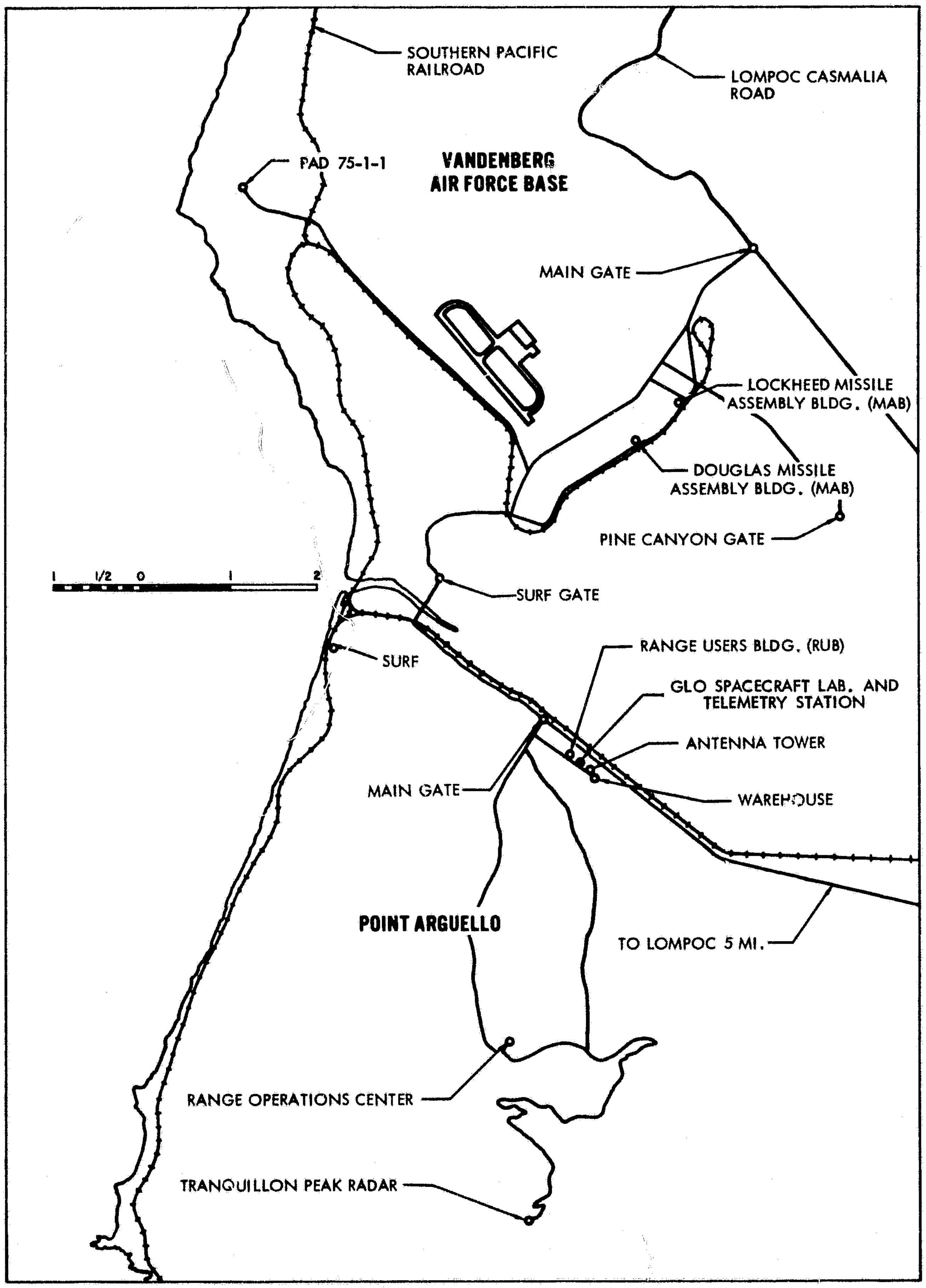


Figure III-1 – Map of PMR Launch Operations Area

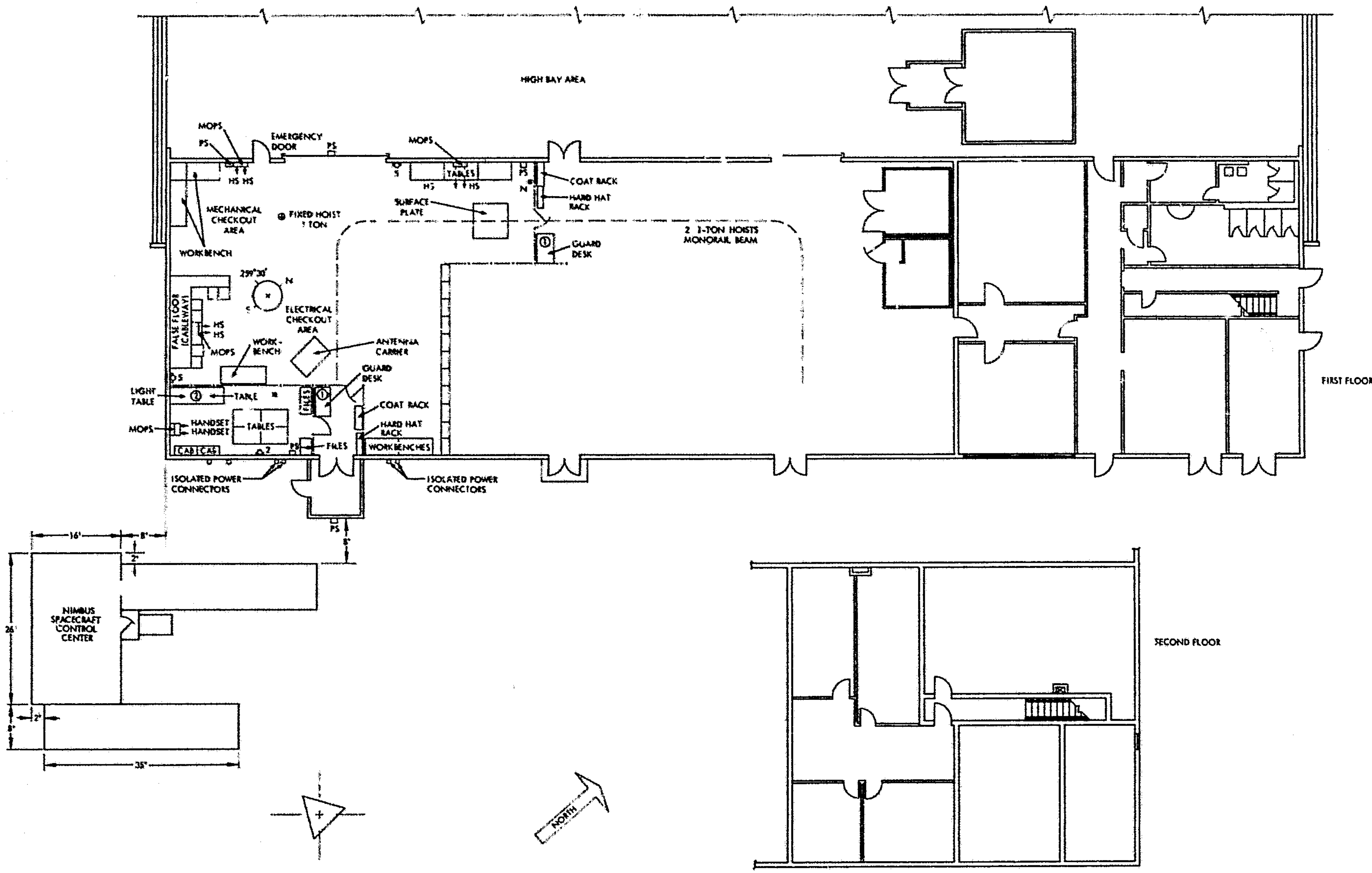


Figure III-2 – Range Users Building

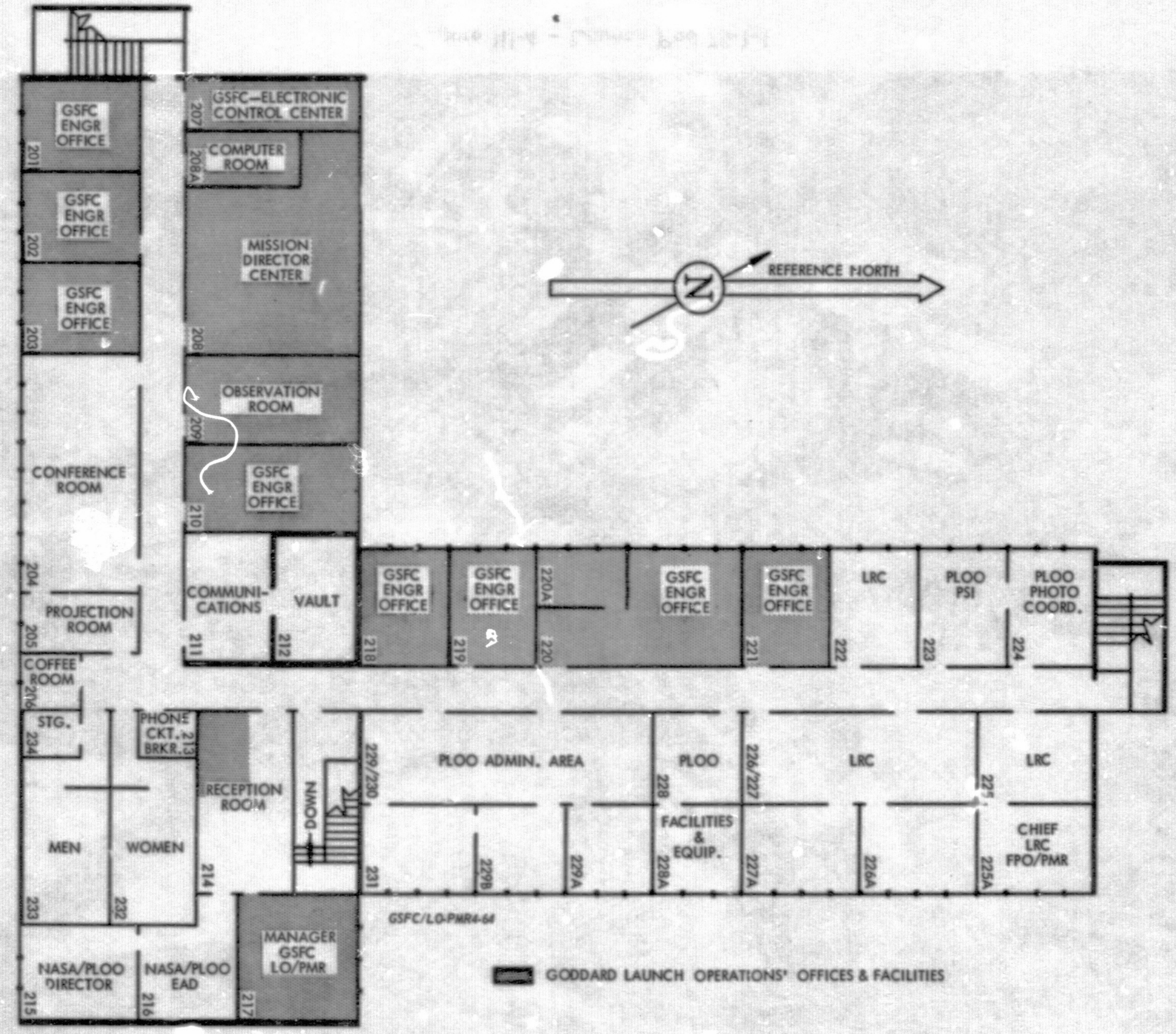


Figure III-3 – GLO Spacecraft Laboratory and Telemetry Station, Nimbus Communications and Facilities

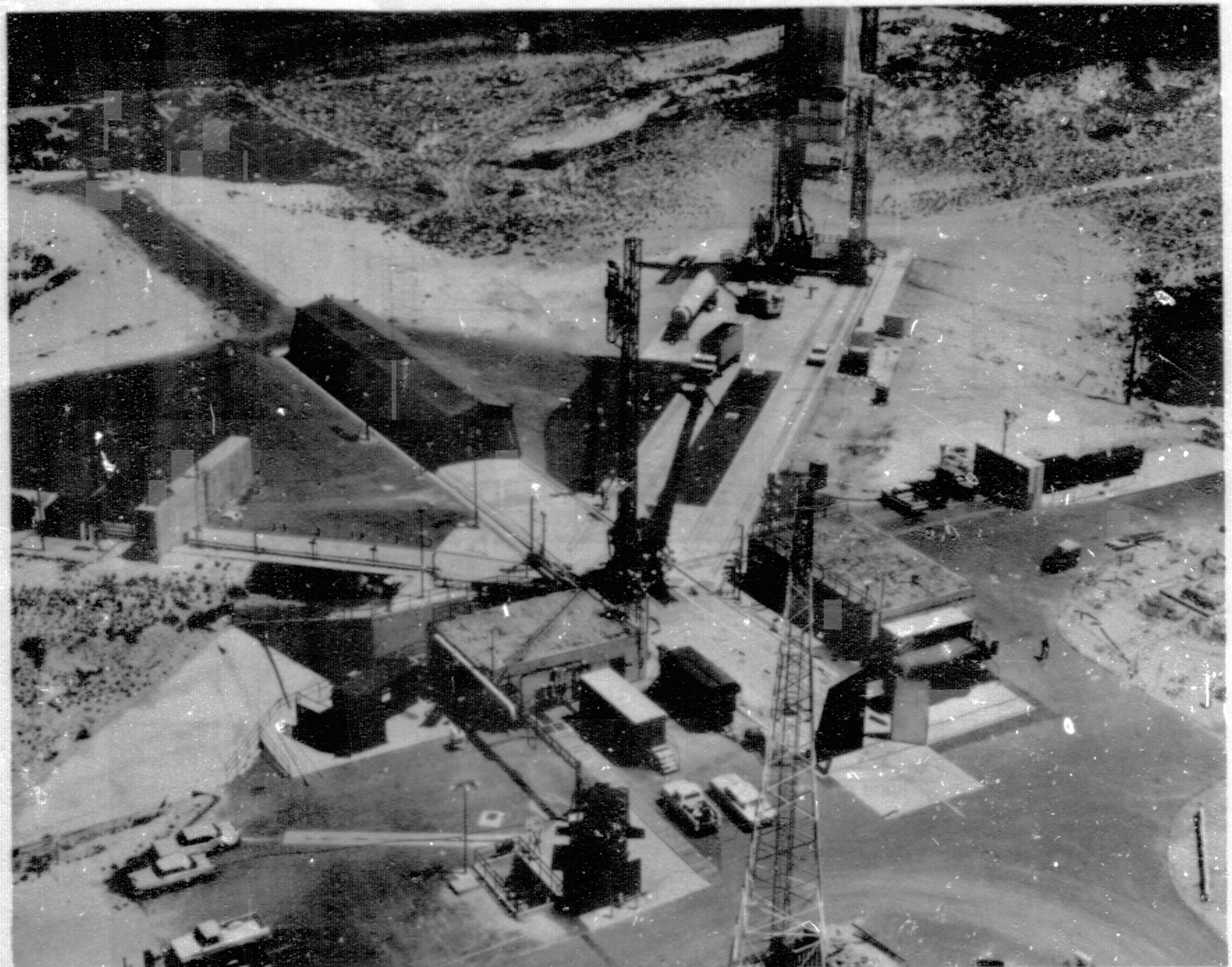


Figure III-4 – Launch Pad 75-1-1

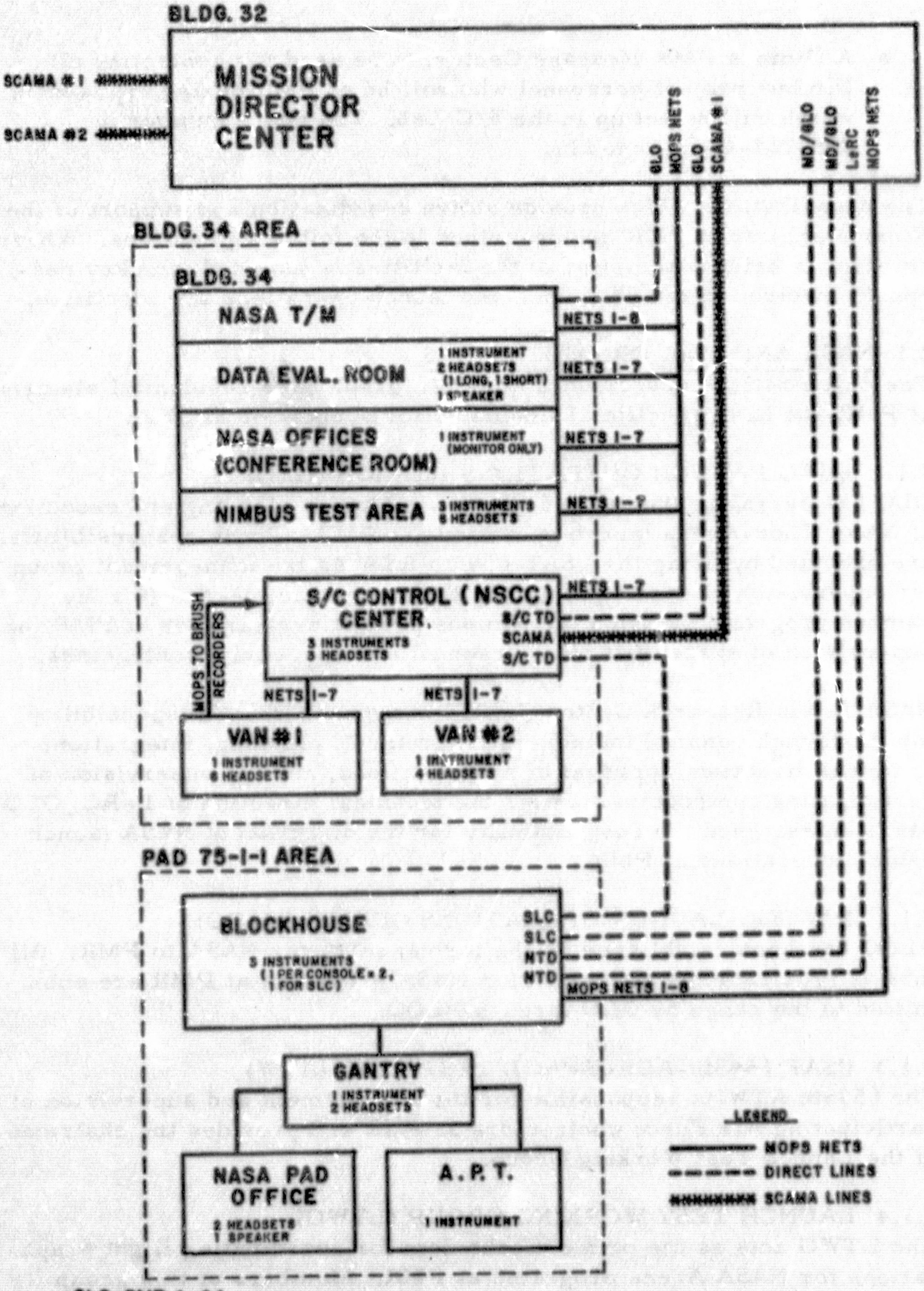


Figure III-5 – Nimbus PMR Communications Net

- A Nimbus PMR Message Center, to be used for contacting all Nimbus project personnel who will be at PMR during the launch, which will be set up in the S/C Lab. The phone number is 805-734-4311, Ext. 217.

The organizations which provide active coordination and support of the Nimbus project at PMR are described in the following sections. Where relevant, a brief description of the facilities is included, and key personnel involved in the prelaunch and launch operations are identified.

2.1 NASA AND PMR ORGANIZATIONS

The organizations described in this paragraph have residential elements at PMR and have specific assignments for support of Nimbus.

2.1.1 GSFC LAUNCH OPERATIONS BRANCH (GLO)

GLO has overall authority and responsibility for planning and execution of NASA Thor-Agena launch operations at PMR. These responsibilities are executed by using the USAF 6595th ATW as the management group for supervision of participating Air Force contractors and (for the Nimbus program) by using the Nimbus project organization at PMR for supervision of spacecraft test personnel and spacecraft contractors.

NASA Lewis Research Center (LeRC) has management responsibility for the launch vehicle, including procurement, planning, integration, technical direction, approval of specifications, and the supervision of participating contractors. Under the technical direction of LeRC, GLO has been assigned the responsibility for the direction of NASA launch vehicle operations at PMR.

2.1.2 PACIFIC LAUNCH OPERATIONS OFFICE (PLOO)

PLOO has been established as the formal entry for NASA to PMR. All formal requirements generated for NASA programs at PMR are submitted to the range by GLO through PLOO.

2.1.3 USAF 6595th-AEROSPACE TEST WING (ATW)

The 6595th ATW is responsible for the management and supervision of participating Air Force contractors at PMR and provides the chairman of the Launch Test Working Group.

2.1.4 LAUNCH TEST WORKING GROUP (LTWG)

The LTWG acts as the prime mechanism for coordinating flight preparations for NASA Agena programs at PMR. Members of this group participate in mission, spacecraft, vehicle, and range-readiness meetings and in day-to-day preparation for launch. The LTWG includes

representatives from 6595th ATW, GLO, PMR, LMSC, DAC, Western Electric Company, and the Nimbus project. The LTWG is chaired by a representative of the 6595th ATW. Direct liaison among all groups is authorized; however, all meetings must be scheduled through the LTWG chairman, and formal agreements can be made only by the LTWG. Minutes of the LTWG are approved and binding on agencies after signature by the Manager, GLO, and the Commander, 6595th ATW.

2.1.5 DOUGLAS AIRCRAFT COMPANY (DAC)

DAC is responsible for the preparation of the Thor SLV-2 vehicle system for launch and the conduct of the SLV-2 portion of the countdown.

2.1.6 LOCKHEED MISSILES AND SPACE COMPANY (LMSC)

LMSC is responsible for the preparation of the Agena vehicle system for launch and for the conduct of the Agena portion of the countdown. In addition, LMSC, under the direction of LeRC, is the systems contractor and is responsible for overall systems analysis and integration of the SLV-2-Agena and Agena-spacecraft interfaces. LMSC is also responsible for the preparation, integration, and coordination of contractually required flight test planning documentation covering the launch-through-injection phase of the Nimbus mission and for the generation of the final ascent trajectory.

2.1.7 WESTERN ELECTRIC COMPANY (WECO)

WECO is responsible for the prelaunch checkout and operation of the launch guidance complex.

2.2 NIMBUS PROJECT AT PMR

The Nimbus project organization for PMR will begin operation at PMR at about R-8 weeks. The Nimbus Project Manager, in the discharge of his responsibility for success of the mission, is supported by a team of GSFC and contractor personnel, all of whom have had continuing responsibility for the design, handling, testing, and evaluation of the spacecraft. The organization of this group is shown in Figure III-6. Technical direction is provided by NASA. General Electric Company is the launch support contractor and will conduct the spacecraft handling, testing, and data analysis.

Additional support is provided by the following contractors for operation of the Nimbus van-mounted ground station equipment and for evaluation of subsystem performance.

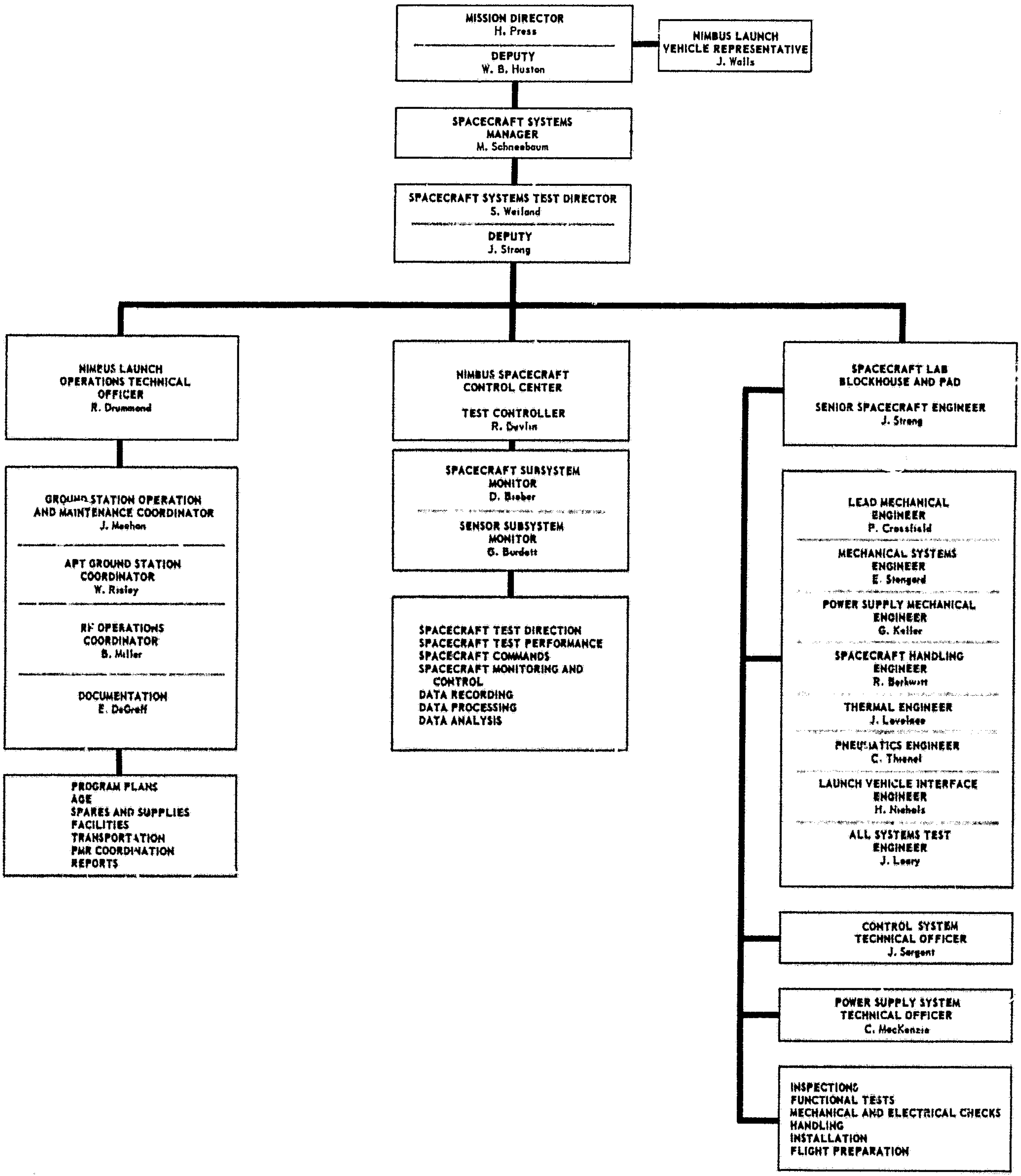


Figure III-6 – Nimbus Spacecraft Launch Organization

Radio Corporation of America - television camera subsystems, power supply subsystem

Radiation, Inc. - PCM telemetry subsystem

California Computer Corporation - command subsystem

Fairchild Stratos - APT van

ITT Industrial Laboratories - HRIR

In all phases of joint test operations involving the spacecraft and the launch vehicle, the Nimbus Spacecraft Systems Test Director will assign senior mechanical or electrical spacecraft engineers to both the blockhouse and the gantry, level 4. These engineers will assist the GLO engineers responsible for coordination of the tests and will be responsible for the Nimbus personnel in the area.

2.3 GSFC MISSION DIRECTOR CENTER (MDC)

The MDC provides the Mission Director and launch group with prelaunch and launch monitoring facilities and the information required to effect a successful mission. The MDC, located on the second floor of the RUB, Building 32, Point Arguello, has an operations room and an observation room. The observation room has seating facilities for 31 people and has a Missile Operations Phone System (MOPS) receiver for monitoring the MOPS nets. MDC operations room assignments are listed below in the order of their console locations. A brief description of responsibilities follows.

1 Meteorological Programs Division representative, NASA Headquarters
2 Agena Launch Vehicle Engineer for Nimbus, LeRC
3 Launch Vehicle System Manager, LeRC
4 6595th ATW representative
5 Nimbus Spacecraft Systems Manager, GSFC
6 Mission Director, GSFC
7 Launch Operations Manager, GLO
8 PMR representative
9 GSFC Communicator, GLO
10 Center Displays Controller, GLO
11 Data Coordinator, GLO

2.3.1 MISSION DIRECTOR

The NASA/GSFC Nimbus Project Manager, H. Press, has responsibility and authority for the overall Nimbus mission. At PMR he is the Nimbus Mission Director responsible for spacecraft, tracking, and data-acquisition aspects of the launch—in the same respect that the NASA Test Director in the blockhouse has responsibility for the vehicle. He is the only person with authority to waive any mandatory mission requirement, whether vehicle, spacecraft, or ground system. He will receive inputs:

- from the NASA Test Director in the blockhouse and the Launch Operations Manager in the MDC concerning launch vehicle readiness, weather conditions, and range support status
- from the GSFC SOCC concerning the status of the NASA STADAN system
- from the Spacecraft Systems Manager concerning spacecraft readiness and status
- from NTCC concerning the status of Nimbus data-handling systems

The Mission Director is at console 6.

2.3.2 SPACECRAFT SYSTEMS MANAGER

The Nimbus project Spacecraft Systems Manager, M. Schneebaum, has overall responsibility for ensuring spacecraft launch readiness. He receives inputs from the Spacecraft Systems Test Director and advises the Mission Director of spacecraft status throughout the countdown. He is at console 5.

2.3.3 LAUNCH OPERATIONS MANAGER

The Launch Operations Manager represents GLO at PMR. He advises the Mission Director on all aspects of the launch operation and range support. He is at console 7.

2.3.4 AGENA LAUNCH VEHICLE SYSTEM MANAGER AND LAUNCH VEHICLE ENGINEER

The Nimbus Launch Vehicle System Manager, S. Himmel, is a member of Lewis Research Center and is responsible for advising the Mission Director on technical matters concerning the launch vehicle. He is at

console 3. He is assisted by the LeRC Agena Launch Vehicle Engineer for Nimbus, P. Winslow, at console 2.

2.3.5 6595th AEROSPACE TEST WING (ATW), AIR FORCE SPACE SYSTEMS DIVISION (AFSSD)

A member of the 6595th ATW, VAFB, is in the MDC to advise the Mission Director on vehicle activity, launch preparations, and countdown operations at VAFB. He is at console 4.

2.3.6 METEOROLOGICAL PROGRAMS DIVISION REPRESENTATIVE, NASA HEADQUARTERS

The NASA Headquarters Meteorological Programs Division representative is in the MDC to inform NASA Headquarters of the status of launch operations. He is at console 1.

2.3.7 PMR REPRESENTATIVE

The PMR representative is responsible for providing the Mission Director with detailed information concerning the status of range instrumentation. He is at console 8 and is in communication with the Range Control Officer at Point Arguello.

2.3.8 GSFC COMMUNICATOR

The GSFC Communicator is responsible for providing GSFC with launch countdown progress, receiving GSFC STADAN station status, and relaying information after liftoff to and from SOCC at GSFC He is at console 9 and is in voice communication with the PMR computer facility at Point Mugu to acquire tracking and early orbit information, which he relays to SOCC at GSFC.

2.3.9 CENTER DISPLAYS CONTROLLER

The Center Displays Controller is a member of GLO at PMR. He operates the center displays panel and assists the Communicator. He is at console 10.

2.3.10 DATA COORDINATOR

The Data Coordinator is a member of GLO. He is responsible for receiving vehicle events and event times from the telemetry stations at Point Arguello and San Nicolas Island (SNI). He is responsible for maintaining communications with GLO at Cape Kennedy to receive AMR status and Agena second-burn reports. He transmits this information to the entire MDC and to the Center Displays Controller. He is at console 11.

2.4 BLOCKHOUSE

The blockhouse CC-1 for pad 75-1-1 serves as the central point for control of the vehicle readiness activities during the pad preparation period, especially on R-3, R-2, and R-1 days, and during other periods of combined vehicle/spacecraft testing. The GLO Spacecraft Launch Conductor will be located in the blockhouse to serve as the focal point for coordination of activities. On R-0 day the following personnel located in the blockhouse will exercise the responsibilities described.

2.4.1 NASA TEST DIRECTOR

The Associate Manager of GLO, J. Schwartz, serves as NASA Test Director in the blockhouse. He has overall authority and responsibility for the conduct of the launch countdown. He receives direct inputs from the AF Launch Control Officer, who is also in the blockhouse, concerning vehicle status and receives inputs from the Range Operations Building, Point Arguello, concerning PMR and AMR support status. The NASA Test Director is responsible to the Mission Director for achieving launch vehicle test objectives and for safely delivering the spacecraft to the injection point. He is in contact with the Mission Director in MDC.

2.4.2 AFSSD LAUNCH CONTROL OFFICER

An officer of the 6595th ATW functions as Launch Control Officer. He has overall authority and responsibility for the conduct of the combined Nimbus launch vehicle countdown and directs the activities of the SLV-2, Agena, and spacecraft launch conductors. He reports launch vehicle status to the NASA Test Director and the 6595th ATW Launch Operations Coordinator located in the VAFB Launch Operations Control Center.

2.4.3 SLV-2 LAUNCH CONDUCTOR

A representative of DAC functions as SLV-2 Launch Conductor. He conducts the SLV-2 portion of the countdown and reports boost vehicle readiness to the Launch Control Officer.

2.4.4 WECO LAUNCH CONDUCTOR

A representative of WECO functions as WECO Launch Conductor and participates in the guidance and control portion of the SLV-2 countdown. He reports readiness of the ground and airborne guidance system to the SLV-2 Launch Conductor.

2.4.5 AGENA LAUNCH CONDUCTOR

A representative of LMSC functions as Agena Launch Conductor. He conducts the Agena portion of the countdown and reports vehicle readiness to the Launch Control Officer.

2.4.6 SPACECRAFT LAUNCH CONDUCTOR

A representative of GLO, J. Weir, functions as Spacecraft Launch Conductor. He coordinates the spacecraft countdown with the other elements of the launch operations, and advises the Spacecraft Systems Test Director in the Nimbus Spacecraft Control Center of countdown progress. He relays spacecraft readiness reports to the Launch Control Officer.

2.4.7 NASA SENIOR SPACECRAFT ENGINEER

The NASA Senior Spacecraft Engineer, J. Strong, is responsible for supervising the NASA Console Operators, and supporting all detailed spacecraft checkout tests at the pad as directed by the Spacecraft Test Conductor at NSCC.

2.4.8 NASA CONSOLE OPERATORS

The NASA Console Operators are responsible to the NASA Spacecraft Engineer for the operation and monitoring of the launch site operational console and the Nimbus console located in the blockhouse.

2.4.9 MISSION REPRESENTATIVE

The chief of the GSFC A&M Division, W. G. Stroud, will represent the Mission Director in the blockhouse. He will be available as necessary for rapid consultation with the NASA Test Director and AFSSD Launch Control Officer on matters affecting fulfillment of the mission.

2.5 GLO SPACECRAFT LABORATORY AND TELEMETRY STATION (S/C LAB)

The S/C Lab, building 34, Point Arguello, is the focal point for all spacecraft operations. The S/C Lab also provides facilities for other flight programs at PMR, and houses the GLO telemetry and Doppler ground station used in support of NASA PMR launches. Included in the S/C Lab area are laboratory facilities for spacecraft checkout, a 450-foot antenna tower for communications with the launch pad, and the Nimbus Spacecraft Control Center. Key personnel assigned to prelaunch checkout and launch operations are as indicated below.

2.6 NIMBUS SPACECRAFT CONTROL CENTER (NSCC)

NSCC (Figure III-7) is the focus of spacecraft test and evaluation operations. NSCC is located at the foot of the 450-foot antenna tower adjacent to the S/C Lab, Point Arguello. It is composed of two vans (Figure III-8): the command/PCM van and the sensory van, and a connecting structure with computer printer, consoles, and desk space for

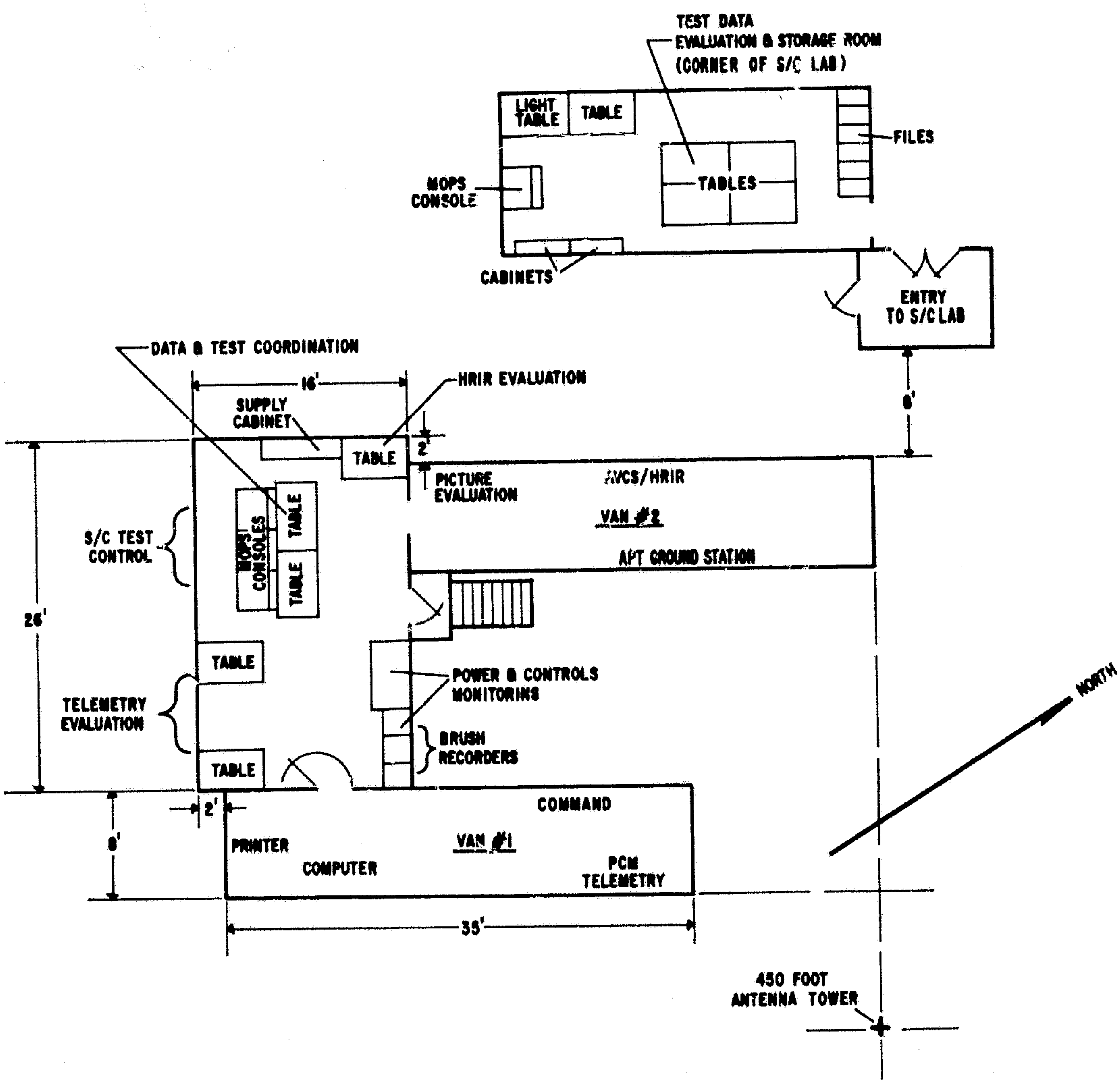


Figure III-7 – Nimbus Spacecraft Control Center

Figure III-8 – Ground Station Vans

the Spacecraft Systems Test Director, the NSCC Test Controller, the Spacecraft Test Conductor, and supporting staff.

During mock countdown and countdown an APT ground station will be considered as part of the NSCC, but will be located near pad 75-1-1 for evaluation of the APT system when the spacecraft is on the launch vehicle. All spacecraft test facilities, including the gantry, will be tied together by MOPS.

2.6.1 SPACECRAFT SYSTEMS TEST DIRECTOR

The NASA Spacecraft Systems Test Director, S. Weiland, is responsible for all spacecraft activities at PMR during prelaunch and launch activities. He will direct the spacecraft portion of the countdown and will report spacecraft status to the Spacecraft Launch Conductor in the blockhouse. He will also report spacecraft status to the Spacecraft Systems Manager for relay to the Mission Director throughout the countdown. He is located at the NSCC.

2.6.2 SPACECRAFT TEST CONDUCTOR

The Spacecraft Test Conductor, E. Smith, is responsible for technical management of the General Electric Company's spacecraft support activities at PMR. He will conduct spacecraft tests, including the countdown tasks, in accordance with approved Detailed Test Procedures (DTP's) and will review and analyze test data. During tests he will coordinate the work of the GE contractor ground station and data analysis groups.

2.6.3 LAUNCH OPERATIONS GROUP

The Spacecraft Systems Test Director is supported by a group of GSFC and contractor personnel. This group will be available during all phases of prototype and flight spacecraft testing. The organization of this group is shown in Figure III-6. During electrical testing, countdown rehearsal and countdown, spacecraft control will be exercised from the NSCC. The NASA Test Controller, R. Devlin, will be in direct control of the NSCC operation, including test conduct and data evaluation. The GE Spacecraft Test Conductor is responsible for the performance of all spacecraft tests. NASA monitors assure conformance to DTP's and participate in and approve data analyses. The NSCC operation will be supported by the California Computer Command Station Operator, the Radiation, Inc., Telemetry Operator, the Fairchild APT Van Operator, the IT&T Radiometer Operator, and by RCA power-supply and GE attitude-control system support groups.

2.7 RANGE SAFETY

The Range Safety Officer at the Range Operations Building will monitor the vehicle trajectory from liftoff through Agena B separation. If, prior to SLV-2 separation, the vehicle exceeds the prescribed range safety limits, the Range Safety Officer will inform the AFSSD Launch Controller in the blockhouse and will command destruct of the vehicle. Range safety requirements are defined in the Flight Termination Systems and Range Safety Reports.

3. SCHEDULES

Coordination of launch vehicle and spacecraft launch preparation is provided by the LTWG through the integrated schedule for vehicle and spacecraft operations. This schedule is prepared in terms of R-days, and assumes one 8-hour shift per day for spacecraft activities and two 8-hour shifts per day for vehicle activities. The schedule is subject to modification to calendar days when the launch date is established or to reflect revisions in vehicle or spacecraft constraints. Revisions will be coordinated with the LTWG by GLO at the request of the Nimbus Project Manager.

The schedules given in this section include the integrated schedule for vehicle and spacecraft operations and the supporting schedules for spacecraft preparation, AGE, the prototype spacecraft, the flight spacecraft, and the flight adapter. These schedules will be supported by the DTP's and the prelaunch, launch, and postlaunch operations described in sections 4, 5, and 6. Detailed launch vehicle schedules are not given in this plan; they are issued by the cognizant launch vehicle groups at PMR.

3.1 INTEGRATED VEHICLE AND SPACECRAFT OPERATIONS

A preliminary integrated vehicle, pad, and spacecraft operations schedule was established in February 1964. Subsequent modifications have been incorporated to reflect a spacecraft requirement for 10 calendar days between the return of the flight adapter after the All Systems Test and the shipment of the flight spacecraft. Highlights of the schedule are listed below.

Item	Agency	Operation	R-Day
1	LMSC	Agena receipt	47
2	LMSC	Agena matchmate	45-43
3	LMSC	Pad Modifications	34-22
4	NASA	Install and checkout blockhouse consoles and gantry equipment	28-22
5	LMSC	Install 136.65-Mc Agena tracking beacon	41
6	NASA	RF-L ık test, S/C Lab to gantry	45-35
7	DAC	Launcher check without booster	29-26
8	LMSC/DAC	Pad cable installation and check-out complete	31
9	LMSC	Agena on stand	21
10	DAC	Leak checks	25-20
11	LMSC/NASA	Compatibilities	20-19
12	LMSC/DAC/NASA	All Systems Test	18-17
13	LMSC/DAC	Mate Agena to booster	16
14	LMSC/NASA/DAC	Matchmate and mate prototype spacecraft (Mock R-3)	14
15	LMSC/NASA	Mock R-2	13
16	LMSC/DAC/NASA	Mock R-1	12
17	LMSC/DAC/NASA	Mock R-0 and RFI	11
18	LMSC/NASA	Demate prototype and Agena	10
19	DAC	Flow tests	9
20	LMSC/DAC/NASA	Mock countdown evaluation	7
21	LMSC	High-pressure functionals	5
22	LMSC	Vehicle weighing and mating preparations	4
23	DAC	Dry count flush and purge, phase and pol.	4
24	LMSC	Final Agena booster mate	4
25	LMSC/DAC	Vehicle erection	4
26	LMSC/NASA/DAC	Matchmate, mate spacecraft	3
27	LMSC	Battery connect, Agena closeup	1
28	DAC	All Systems Run	1
29	NASA	Spacecraft checkout	1
30	LMSC/DAC/NASA	Countdown	0

3.2 SPACECRAFT PREPARATION AND PRESHIPPING CHECKS

A specific sequence of spacecraft checks is required before placing the prototype and flight spacecraft in their vans (Figure III-9) for shipment to PMR. The intent is to establish a data reference base for diagnosis of the effects of transportation and handling of the spacecraft enroute to PMR. Immediately upon spacecraft arrival at PMR, identical postshipping checks will be made in reverse sequence. Direct comparison of these data with the preshipping data will be used to highlight changes that may have been induced during the transport phase.

If malfunctions occur during the preshipping spacecraft checks, the spacecraft will be repaired and requalified before the sequence of checks is again initiated.

Specific Preshipping Sequence

Item	Operation
a	Spacecraft completely qualified
b	Check with matchmate tool
c	Mount on test and calibration dolly
d	Leak check, control system pneumatics
e	Structural alignment check
f	Spacecraft go/no-go check
g	Paddle electrical functional check
h	Battery check
i	Pull battery plug
j	Final visual inspection (check list)
k	Install spacecraft cover
l	Load spacecraft in transport van
m	Humidity protection and environmental instrumentation
n	Ship to PMR

3.3 PROTOTYPE SPACECRAFT SCHEDULE

The prototype spacecraft will be mounted on the prototype spacecraft adapter at GE, placed in the van with humidity control, and air-shipped to PMR. In all details of handling and test, flight spacecraft procedures will be used in order to verify the readiness of hardware, procedures, and people to support the flight operation. During a portion of the prototype test phase at PMR, the spacecraft will be removed from its adapter and placed on the check-of-calibration adapter in order to compare sensor calibrations with those previously obtained at GE. The schedule for the prototype is:

Figure III-9 – Spacecraft Transport Trailer

Item	Operation	Time
1	Prototype spacecraft at VAFB; unload space craft van	R-27
2	Tow spacecraft van to S/C Lab	R-27
3	Unload spacecraft from van, remove cover, move to lab	R-27
4	Evaluation, transport and handling effects	R-27 to R-18
	a Analyze recorded environmental data	R-27
	b Complete visual check (check list)	R-26
	c Install battery plug	R-26
	d Check batteries	R-26
	e Electrical go/no-go check On test and calibration dolly	R-26
	f Solar array electrical functional check	R-26
	g Structural alignment check	R-25
	h Leak check, controls pneumatic system	R-24
	i Adapter matchmate check (on surface block)	R-23
	j Demate from prototype adapter, check spring alignment	R-23
	k Mate to alignment fixture, check sensor alignment	R-22
	l Mate to check-of-calibration adapter	R-22
	m Deploy solar array paddles	R-21
	n Spacecraft functional checks (post-environmental test procedure)	R-20 to R-19
	o RF power and command receiver sensitivity	
	p Refold solar array paddles	R-18
5	Data review and status evaluation	R-18
6	Alignment of springs and mate to prototype adapter, mount on test and calibration dolly	R-17
7	RF link, controls, go/no-go, and sensory ring confidence checks in S/C Lab	R-16 to R-15
8	Visual inspection, charge pneumatics, install humidity bag, install spacecraft covers, load spacecraft in van	R-15
9	Tow to launch pad, mate prototype spacecraft to Agena, and conduct RF-link checks* as follows:	R-14

Item	Operation	Time
	Spacecraft to NSCC Spacecraft to APT ground station — Gantry in place No shroud	
10	Mock R-2 day activities	R-13
11	Mock R-1 day activities	R-12
12	Mock countdown (R-0 day activities) plus RFI check	R-11
13	Exercise gantry to spacecraft gas-charging equipment	R-11
14	Demate spacecraft and return to S/C Lab	R-10
15	Spacecraft electrical go/no-go check — On test and calibration dolly; tests to be on a noninterference basis with the flight spacecraft.	R-9
16	Structural alignment check	R-8
17	Leak check, controls gas	R-7
18	Solar array electrical functional check	R-6
19	Battery check and discharge Pull battery plug	R-6
20	Store spacecraft in transport van	R-5

*Additional RF-link checks will be performed with shroud on and gantry in place, or pulled back. These checks will be incorporated in detailed tasks for R-13, R-12, R-11.

3.4 FLIGHT SPACECRAFT SCHEDULE AT PMR

The flight spacecraft will be shipped to PMR near the completion of the prototype spacecraft checkout and postshipping qualification. The schedule for the flight spacecraft is planned to provide a minimum of handling of the spacecraft and to ensure that air shipment has not caused undetected changes in the qualification and readiness of the spacecraft.

The flight spacecraft schedule is geared to the All Systems Test, which involves use of the adapter and its prompt return to GE. A minimum of nine spacecraft working days are required between the completion of the All Systems Test and arrival of the flight spacecraft at PMR.

The Mission Director will hold a spacecraft evaluation meeting on R-0 day prior to the beginning of the countdown for the purpose of detailed review and buy-off of the spacecraft confidence tests performed on R-1 day. Participants will include the Spacecraft Systems Manager, the Spacecraft Systems Test Director, and all persons involved in the data analysis activities.

Flight Spacecraft Schedule

R Day	Event
R-16	Flight adapter arrives at GE from All Systems Test, Inspect adapter
R-15 (& Saturday)	Matchmate adapter, install epoxy shim
(Sunday)	Install separation springs
R-14 & R-13	Vibration and confidence test
R-12	Leak check
R-11	Alignment check and visual inspection
R-10 (& Saturday)	Preshipment preparation
(Sunday)	Ship to PMR
R-9	Spacecraft arrival
R-8	Postshipping verification
R-7	Alignment and leak check
R-6	Matchmate tool check, battery conditioning
R-5	Battery conditioning
R-4	Spacecraft check, launch preparation
R-3	Tow to pad, mate to Agena
R-2	Shroud and pyro installation, spacecraft checks
R-1	Shroud final installation and spacecraft confidence test
R-0	Spacecraft evaluation meeting
R-0	Countdown initiation

A detailed schedule of events for the flight spacecraft, with task definitions, will be released by the Nimbus Launch Operations TO, R. Drummond.

3.5 FLIGHT ADAPTER SCHEDULE

The flight adapter is required at PMR for the Agena compatibility and All Systems Tests with the launch vehicle and flight shroud prior to the arrival of the flight spacecraft. Since the flight adapter is required for the preshipment tests at GE in the period R-16 to R-10 and is mated to the spacecraft for shipment to PMR, a closely coordinated schedule of

flight adapter shipment and use at PMR and at GE-MSD, Valley Forge, is required. The schedule is as follows:

Flight Adapter Schedule

Item	Operation	Time
1	Flight adapter and spacecraft simulator at PMR	R-21
2	Agena electrical compatibility check	R-20 to R-19
3	All systems check at pad (utilizes flight adapter, flight shroud and spacecraft simulator)	R-18 to R-17
4	Ship flight adapter to GE-MSD	R-17

3.6 GROUND STATION VANS AND AGE SCHEDULE

The ground station vans and aerospace ground equipment are required at PMR in order to conduct prototype and flight spacecraft tests and to conduct launch personnel training exercises prior to the launch operation. To assure compatibility of the vans and ground station equipment with the flight spacecraft, it is required that the vans support the spacecraft analysis prior to and after the flight acceptance vibration test. On arrival at PMR the vans will be tied into an existing interconnecting structure, MOPS circuits installed, and the whole will become the Nimbus Spacecraft Control Center (NSCC). A schedule of events for use of the ground station vans and the AGE follows.

Ground Station Vans and AGE Schedule

Item	Operation	Time
1	APT ground station van and antenna trailer at PMR	R-40
2	Nimbus ground station vans at PMR	R-40
3	Van installation and checkout, assembly of vans and control room to form the NSCC	R-40 to R-35
4	Install communications network	R-40 to R-30
5	Install and checkout AGE in S/C Lab (except specific consoles involved in final spacecraft tests at GE-MSD)	R-40 to R-27

Item	Operation	Time
6	Matchmate tooling check in S/C Lab (GE and LMSC tools)	R-35
7	Install blockhouse consoles, checkout consoles, and gantry equipment	R-28 to R-22
8	Conduct RF-link tests (NSCC to gantry)	R-45 to R-35
9*	Complete S/C Lab console installation	R-30 to R-27
10	NSCC and all AGE in S/C Lab operational	R-27
11	Support of spacecraft checks (prototype and flight spacecraft)	R-27 to R-0

*Note: Spacecraft test consoles for installation in the S/C Lab at PMR will be utilized for the prototype spacecraft final checks at GE-MSD. These consoles will be shipped to PMR with the spacecraft.

4. PRELAUNCH OPERATIONS

Prelaunch schedules are listed in section 3, above. In addition, the following operations are required.

4.1 LAUNCH VEHICLE

Launch preparation of the Thor and Agena is under the cognizance of the DAC and LMSC launch groups at PMR. The operations of these groups are in accordance with Detailed Test Procedures (DTP's) established for use at PMR, as required by the Air Force and LeRC, with monitoring and coordination by GLO.

4.2 LAUNCH COORDINATION LETTER AND TELETYPE

On or before launch minus 10 days, a launch coordination letter will be sent out by LMSC Sunnyvale confirming all applicable launch documents on the Agena B and documenting any changes in launch criteria. On or before R-4 days, a final launch criteria teletype will be sent listing the final binary settings and scale factors on the Agena B velocity meter, guidance pot settings, etc., and also reconfirming information in the launch letter. The distribution on the letter and teletype will include LeRC, LMSC VAFB, and GLO.

4.3 COMBINED TEST OPERATIONS

During the prelaunch phase, a requirement exists for combined vehicle/spacecraft operations involving joint participation of vehicle contractors

and spacecraft personnel. Early preparation of joint test procedures issued by LMSC VAFB and GE will be coordinated by GLO and the Nimbus project. These joint test procedures cover

- Matchmate
- Pad validation
- All Systems Test
- Pad rehearsals and RF compatibility

The combined test operations will be performed to assure complete integration and compatibility of the launch vehicle and spacecraft systems. The pad rehearsals, in particular, beginning on R-14, will provide a complete exercise of all phases of the launch operation including transport of the spacecraft to the gantry, installation on the Agena, shroud installation, and spacecraft evaluation. This rehearsal will time the spacecraft events, rehearse crews, check procedures, and evaluate the RF link to the 450-foot antenna tower.

4.4 SPACECRAFT PROCEDURES

4.4.1 DETAILED TEST PROCEDURES

To support the scheduled tests of the prototype and flight spacecrafts at PMR, detailed procedures have been prepared by General Electric, under the direction of the Spacecraft Test Conductor, and approved by the Spacecraft Systems Test Director or his deputy. The detailed test procedures required are:

Post-environment test
Spacecraft handling and shipping
Van readiness checkout
Spacecraft/van RF check
Matchmate tool/adapter check in S/C Lab
Pad validation
PMR equipment compatibility
Check of alignment
Check of sensor alignment
Paddle deployment
Pneumatic leak
Sensory ring confidence test
Spacecraft/shroud clearance check
All Systems Test
Controls go/no-go

4.4.2 SPACECRAFT ACCESS

The entrance to the S/C Lab and NSCC will have a 24-hour guard, provided under the GLO watch service contract. The Nimbus project office will furnish the guard with an access list. Specific authorization must be obtained for visitor access.

4.4.3 TRANSPORT TO THE PAD

During periods when the prototype or flight spacecraft is being transported to or from the pad, it will be placed on the test and calibration dolly and placed in the spacecraft van. The prime mover and an armed escort will be provided by PMR in accordance with the requirements placed on PMR in the Operations Requirements document, OR A322B0000 dated February 1964, prepared by GLO.

4.4.4 GAS CHARGING

Two transportable, high-pressure gas storage carts will be provided by GLO. Each contains four 1-cubic foot capacity vessels of freon 14. The vessels will be filled by LMSC to 2500 psig and a sample will be taken to ensure that the freon hasn't been contaminated. One cart will be used in the S/C Lab for charging the prototype and flight spacecraft attitude control system to 1250 psig. The second cart will be used at the pad for emergency topping-off or filling as required.

Commercial grade A helium will be used for leak testing in the S/C Lab at 1250 psig. The entire pressurization system has been proof-tested to over 5,000 psig; therefore no special pressure vessel safety procedures are required either in the S/C Lab or at the pad.

4.4.5 SPACECRAFT COOLING AT THE PAD

At all times when the prototype or flight spacecraft is on the Agena with the shroud in place, cooling air will be supplied through an air-conditioning inlet fitting near the top of the shroud. The pad facilities will supply air at temperatures controllable down to 10° C (50° F), at flow rates up to 60 lbs. per minute. Spacecraft temperature will be monitored over the spacecraft telemetry system which, with its readout equipment, provides the NASA Test Director with an average spacecraft temperature based on 60 thermistors located at critical points in the spacecraft structure. The temperature of the sensory ring and the attitude control system must not exceed 45° C (113° F) or fall below 10° C (50° F). The temperature of the solar paddles is not of concern. The NASA Test Conductor will monitor the spacecraft temperature and

request adjustment of the pad cooling air temperature or flow rate as required. These requests will be directed to the GLO Spacecraft Launch Conductor.

4.4.6 ELECTRO-EXPLOSIVE DEVICES (EED)

There are two kinds of spacecraft electro-explosive devices (EED) to be considered during PMR operations: the separation band bolt cutters and the cable cutters in the paddle unfold release mechanism. The configuration of each EED in each handling phase will be as follows:

Transportation and shipping

Bolt cutters assembled, armed, shorting caps in place (adapter connectors protected for shipment)

Cable cutter assembled, squibs installed with shorting caps (timer output to cutter disconnected, protected for shipping)

RFI Test (Mock Coutdown)

Bolt cutters assembled, not armed, with shorting caps. Redundant, parallel bolt cutter assemblies will also be installed in such a manner that firing cannot initiate spacecraft separation. These bolt cutters will be armed and electrically connected to the Agena firing circuits.

Cable cutter assembled, armed, connected in normal spacecraft configuration with protective mechanical device clamping paddles to support

Launch

Bolt cutters will be checked and connected by LMSC pyrotechnic installation technicians

Cable cutter will be checked and installed by the spacecraft technicians

4.5 COMMUNICATIONS

All spacecraft tests at the pad will be conducted over the MOPS net. For test activities in the S/C Lab, the MOPS net will be utilized as a spacecraft intercom system.

The Detailed Test Procedures are prepared in a format to facilitate conduct of the tests over the MOPS nets. All participants will exercise communications discipline during scheduled test periods. During test periods the MOPS nets will be tape recorded to provide an input to failure analysis if required.

In addition to the usual range communications facilities for a PMR launch, a special Project Manager's conference line will link the Project Manager at PMR with GSFC NTCC and GILMOR NDHS, beginning with the initiation of the countdown at approximately R-10 hours. This line will utilize SCAMA or commerical circuits as established by NETCON procedures. This line will be given a readiness check during the countdown rehearsal on R-11. For other GSFC communications in direct support of PMR, special procedures will apply, as illustrated in the following schedule.

Communications Countdown

Action	Count
NTCC will relay to the MDC status reports which have been received from NETCON and NDHS	T-480 and T-170
Telety_e Mission Minimize will be imposed by NETCON	T-120
NTCC will perform the same procedures as at T-480 and T-170	T-120
Establish special phone circuits from MDC to SOCC and Project Manager's conference line	T-60 (1 hour prior to scheduled liftoff)
All stations will send readiness reports to NETCON	
SOCC receives satellite frequencies and all pertinent prelaunch information by phones and teletype from MDC. NETCON relays the information to all activities.	T-50 to T-0

5. LAUNCH OPERATIONS

Launch operations include all activities from the initiation of countdown on R-0 day through early orbit tracking. The countdown is conducted by the NASA Test Director in the blockhouse, beginning at 10 hours 30 minutes before the opening of the launch window (approximately 2:30 p.m. PDT or 2130 GMT). Figure III-10 shows the integrated countdown tasks as established at the launch operations planning meeting in February 1964. The chart shows the tasks to be performed by the NASA, DAC, and LMSC Test Conductors. The principal constraint in the preparation of the countdown schedule was the requirement that the go/no-go check, task 3, be completed in 150 minutes so that it can be repeated, if necessary, prior to the initiation of Agena tanking. Another constraint places the switch to spacecraft internal power late

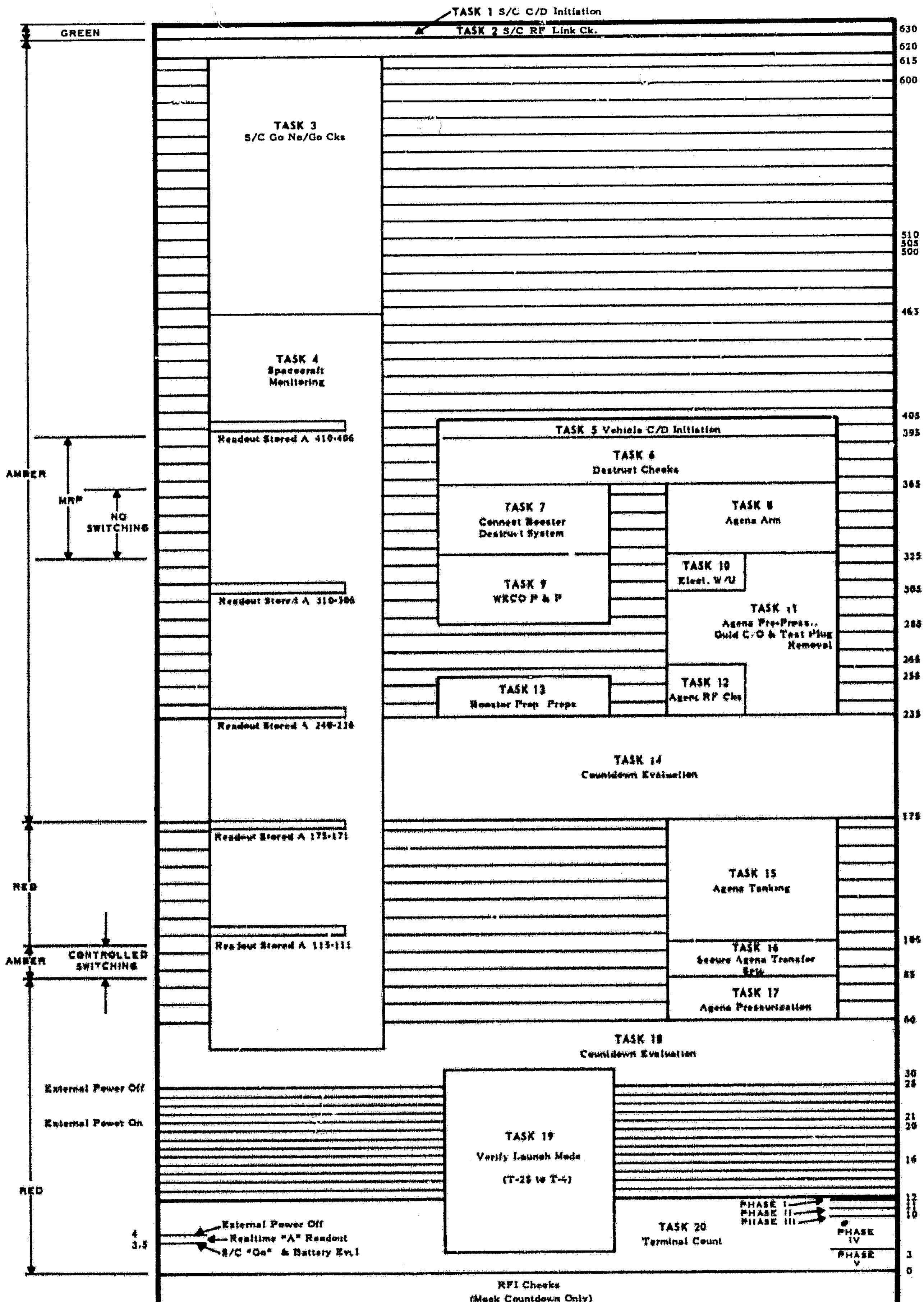


Figure III-10 – Integrated Countdown Chart

in the countdown, task 19, so as to provide a maximum of useful battery power in orbit. Spacecraft status will be monitored through real-time-A continually, and, at the times designated on the chart, stored-A-telemetry will be read out. The integrated countdown chart will be revised as necessary before launch to reflect changes in schedules.

5.1 LAUNCH CONSTRAINTS

Launch constraints as specified in the System Test Objectives include:

- Launch Window

  The optimum time of injection is determined by the condition that the angle between the orbit plane and the earth-sun line (apparent sun) be zero. Such a value of orbit solar angle would produce maximum performance of the solar power supply. The time of injection changes with solar declination and the "Equation of Time"; it is latest in July, earliest in November. The relationship between time of injection and launch time is fixed by the 54.9-minute period between liftoff and the end of Agena second burn.

  The launch window, which defines the permissible departure from the optimum time of liftoff, is fixed by the allowable reduction, 1 percent, in the illumination intensity on the solar paddles, a criterion which is satisfied if the orbit solar angle lies within limits of $\pm$ 8.1 degrees (cos 8.1 = 0.990). A list of approximate times of launch window opening and closing, together with the optimum liftoff time, is given below, for planning purposes. Final values for the actual day of launch will be provided by LMSC.

Launch Window

(All times PDT)

Date		Opens	Optimum	Closes
June	21	0105	0141	0217
	25	0106	0142	0218
	30	0107	0143	0219
July	8	0108	0144	0219
	24	0108	0143	0218
August	1	0107	0141	0216
	6	0106	0140	0214
	9	0105	0139	0213
	12	0104	0138	0212
	15	0103	0137	0211
	18	0102	0136	0209
	20	0101	0135	0208
	23	0100	0133	0207
	25	2459	0132	0205
	27	2458	0131	0204
	29	2457	0130	0203

- The following primary subsystems must be operational before launch:

  a. Thermal control
  b. Attitude control
  c. Power supply
  d. Command clock
  e. Command capability
  f. Telemetry
  g. AVCS and APT
  h. HRIR

- Spacecraft separation devices monitored through Agena telemetry system must be operational

- GILMOR, ROSMAN, WNKFLD, and JOBURG STADAN stations, including communications, must be operational

- NTCC and NDHS at GSFC must be operational

5.1.1 SPACECRAFT

Any hold after T-25 which exceeds 5 minutes duration will require a recycle in task 19 to return the spacecraft to external power. The details of this recycle are given in the countdown manual.

R-1 day:	Any malfunction will result in a spacecraft hold.
T-10 hours:	A complete go/no-go test will be initiated. Any malfunction during the go/no-go test will cause a hold.
T-25 min:	A hold will be called as needed to bring the spacecraft batteries to at least 90 percent of full charge before umbilical disconnect.

5.2 LAUNCH SEQUENCE

The sequence of events from launch to injection is shown in Figures III-11 and III-12. Figure III-13 shows the launch trajectory.

5.3 TRAJECTORY TRACKING

Full launch-vehicle telemetry and tracking coverage is required from liftoff through Agena first burn, and from 10 seconds before Agena second burn through spacecraft injection and separation. No tracking or telemetry is planned during the Agena coast phase; however, the coverage outlined above will furnish spacecraft acquisition data to the tracking net and, in addition, will permit postflight determination of launch vehicle system performance.

The AMR station 13 in Pretoria will provide Agena vehicle telemetry coverage of second burn and separation. The STADAN station at Johannesburg (JOBURG) will acquire the Nimbus 136.5-Mc beacon and the Agena 136.65-Mc beacon and will notify SOCC, for relay to MDC. JOBURG will evaluate the spacecraft beacon to determine the spacecraft clock time and will report to SOCC for relay to NTCC. The beacon telemetry will be taped at Johannesburg and the tapes will be shipped to GSFC.

The STADAN station at Winkfield will monitor the Nimbus beacon to determine whether stabilization has occurred by monitoring the AGC records and will make a voice report to SOCC.

The launch will be covered by the phototheodolites at Point Arguello and VAFB to an altitude of approximately 5000 feet. At this point, the phototheodolites at Santa Cruz and San Nicolas Islands, the FPS-16 beacon track radars at Point Arguello, Point Mugu, and San Nicolas Island, and the COTAR'S at VAFB and Point Mugu pick up track.

Data from the launch-support facilities at PMR and from AMR will be sent to the GSFC Data Systems Division where the launch trajectory will be computed for use in orbit refinement.

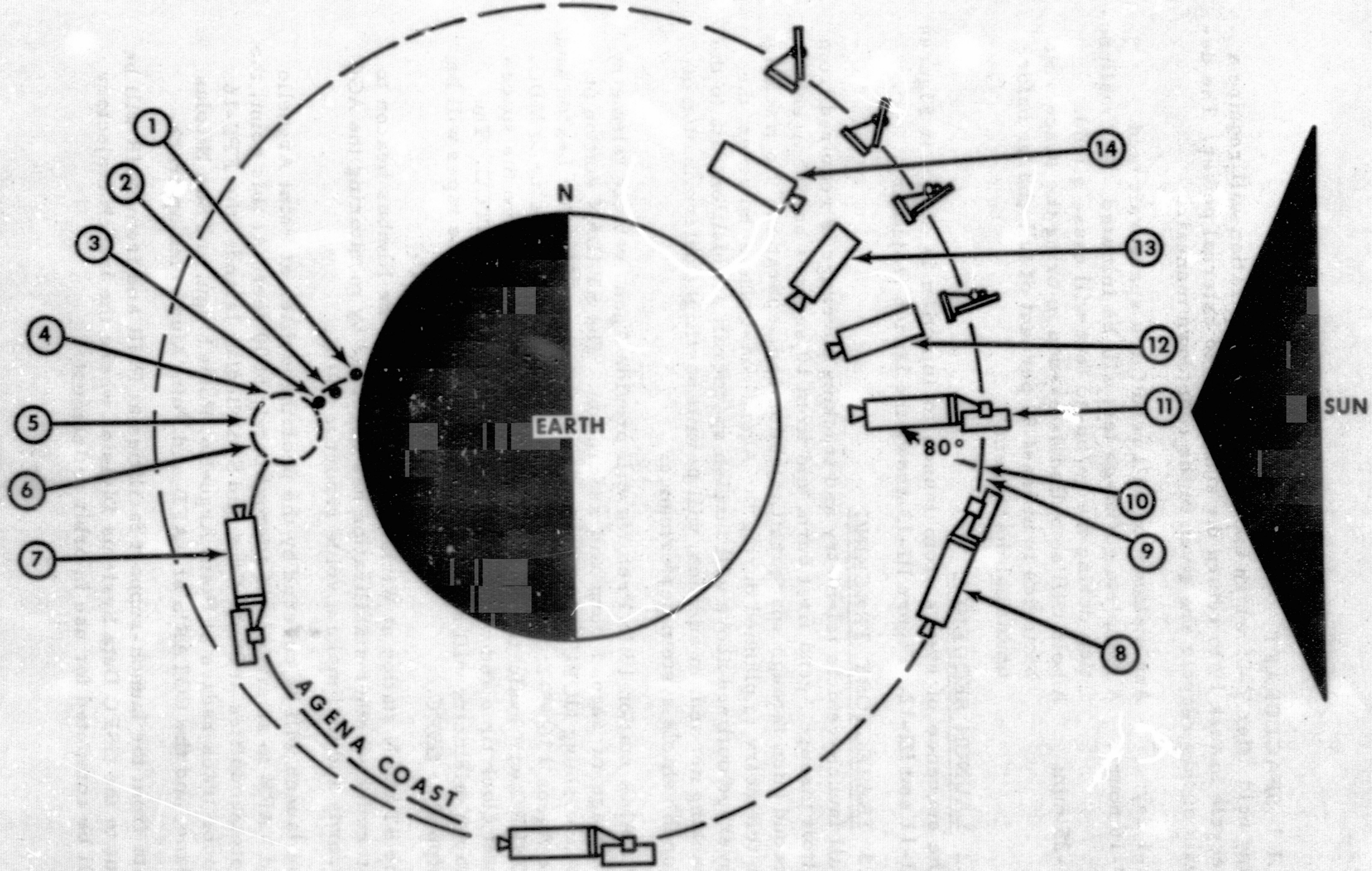


Figure III-11 – Launch Sequence Diagram

EVENT NO.	EVENT	COMMANDS	APPROXIMATE TIME (in Seconds)
1	Launch from VAFB	Liftoff and umbilical disconnect	0
2	Thor main engine cutoff (MECO)	Thor cutoff	148.5
3	Thor vernier cutoff (VECO)	WECO	157.5
4	Thor/Agena separation	Guidance	164.8
5	Agena first burn	D-timer	190.3
6	Nose shroud separation	D-timer	195
7	Agena first cutoff	Velocity meter	427.27
8	Agena second ignition	D-timer	3292.3
9	Agena second cutoff	Velocity meter	3295.1
10	Initiate 60°/min. pitchup maneuver	D-timer	3306
11	Terminate pitchup	D-timer	3386
12	Separate spacecraft	D-timer	3408
13	Initiate pitchdown	D-timer	3418
14	Terminate pitchdown	D-timer	3458

Figure III-12 – Launch Events and Times*

*Based on LMSC document 1332152 Revision E

The Agena 136.65-Mc beacon will be tracked by the STADAN net for three to five days to provide the GSFC Data Systems Division with information for a special study of Agena/spacecraft separation.

5.4 ORBIT TRACKING

The U. S. Naval Space Surveillance System, North American Defense Command (NORAD), and the Smithsonian Astrophysical Observatory network are requested to use their tracking facilities to track the Nimbus spacecraft during the first week after launch and to forward tracking data via TTY and/or telephone to GSFC as soon as possible.

STADAN will send all raw data to the GSFC Data Systems Division. From these data, the orbit will be refined and ephemeris predictions will be sent to STADAN and APT stations.

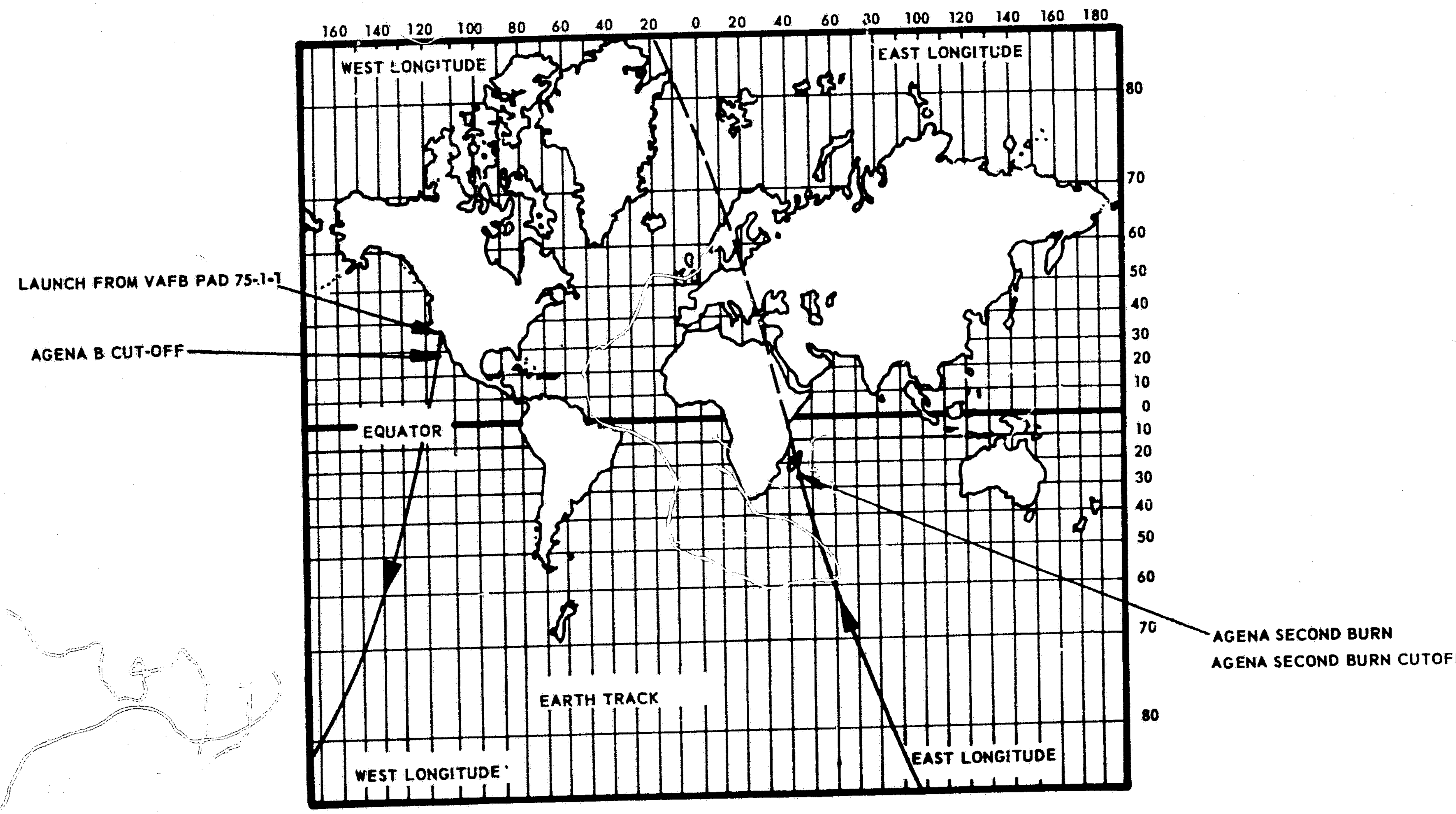


Figure III-13 – Nimbus Launch Trajectory

6. POSTLAUNCH OPERATIONS

Range operations are completed when the spacecraft orbit has been determined and updated predictions have been computed by GSFC Data Systems Division and forwarded to the STADAN and APT stations.

Spacecraft operational control after liftoff is transferred to NTCC. During the first 5 orbits, close liaison will be maintained between MDC and GSFC NDHS and GILMOR NDHS via the Project Manager's conference line. The Spacecraft Systems Test Director and other spacecraft specialists will be available for consultation.

Postlaunch quick-look evaluation of the various phases of the launch test operation will be made by NASA and AFSSD at VAFB immediately after the vehicle launch. These initial evaluations will be based on a review of the available direct write telemetry data and playbacks of all telemetry parameters and trajectory information. These data are to be available to NASA LTWG, in usable preliminary form, by T+6 hours. Decisions will be made by the NASA Test Director as required and a plan of action will be formulated to direct further data processing and evaluation by the participating agencies and contractors as necessary.

7. PMR DOCUMENTATION

Most of the documents listed below are coordinated by representatives from several interested offices; only the office responsible for final preparation and printing is listed here.

7.1 RANGE DOCUMENTATION

Program Requirements Document (PRD)

Prepared by GLO.

The PRD defines those program needs which are levied upon the range by the range users and constitutes the request for the range to perform those functions in support of the program.

Program Support Plan (PSP)

Prepared by PMR.

PMR's response to the Program Requirements Document is the PSP, which describes the proposed action to meet each stated requirement. It states which requirements can be met from existing resources, which can be met by programming for support capability, and which cannot be met.

Operation Requirements (OR)

Prepared by GLO.

The OR supplements and follows the PRD by describing in greater detail final test information, services, and related requirements for accomplishing an individual test or test series within the overall program.

Operation Directive (OD)

Prepared by PMR.

PMR's response to the OR is the OD. It collectively mobilizes final resources to support requirements necessary for the test series.

7.2 LAUNCH TEST DOCUMENTATION

Systems Test Objectives (STO)

Prepared by LMSC.

The STO constitutes the basic flight test planning document for the preinjection phase of the Nimbus program.

Launch Test Directive (LTD)

Prepared by LMSC.

The LTD covers the flight testing of the spacecraft, Agena B, and SLV-2 and outlines in detail the mandatory preflight tests to be performed on the vehicle.

Flight Termination Systems Report (FTR)

Prepared by LMSC.

The FTR provides the range with an overall description of the space vehicle destruct system, including wiring diagrams and photographs and a summary of test results that will show capability of the system to perform its destruct functions adequately.

Range Safety Report (RSR)

Prepared by LMSC.

The RSR provides the range with the nominal trajectory data and dispersion patterns resulting from malfunction or explosion during the ascent phase.

Pad Safety Report (PSR)

Prepared by LMSC.

The PSR provides information on the pyrotechnics and ordnance items, the propellant and pressurization system, and the flight termination system associated with the vehicle.

7.3 LAUNCH DOCUMENTATION

Countdown Manual (CDM)

Prepared by LMSC/VAFB

The CDM represents in a logical sequence the integrated launch vehicle, spacecraft, ground support equipment, and instrumentation items that are to be performed from countdown initiation through launch to effect a successful launch. The countdown is initiated and conducted by the Launch Control Officer. Specific vehicle and spacecraft checks are conducted as "Tasks" to the countdown manual. The Launch Control Officer directs task initiation through the vehicle or spacecraft launch conductors.

PART IV

GSFC OPERATIONS

At GSFC, the Aeronomy and Meteorology (A&M) Division is responsible for the control of all aspects of the Nimbus spacecraft, including establishing priorities for spacecraft meteorological and engineering data collection, handling, and evaluation. The Nimbus Operations Manager, R. Shapiro, has overall responsibility for directing the Nimbus ground system operations and spacecraft management and evaluation, as shown in Figure IV-I, Nimbus Operations Organization. The Tracking and Data Systems (T&DS) Directorate is responsible for operation of the network of tracking and data-acquisition stations, the ground communications system, and orbital computations and predictions. The Project Resources Office will assure support of Nimbus by the Tracking and Data Systems Directorate. The Tracking and Data-Acquisition Systems Manager represents the directorate as sole representative to the project. All communications with the project shall be coordinated by him. The Tracking and Data-Acquisition Systems Manager will be responsive to the Project Manager, assuring him of effective participation by T&DS wherever required. He will support the Nimbus Operations Manager, assuring him of effective participation by T&DS. After launch the Tracking and Data-Acquisition Systems Manager will be cognizant of all operations, but the Ground Operations Manager will be responsible for daily operations of the T&DS in support of Nimbus.

1. COMMUNICATIONS

The NASA communications (NASCOM) network provides the ground communications support for all NASA spaceflight programs. The T&DS NASA Communications Division operates the NASCOM network and issues the NASCOM operating procedures (NASCOP). The NASCOM global network includes all of the circuits, terminal, and switching equipments which interconnect tracking and data-acquisition stations with mission centers, project control centers, computing centers, etc. All global circuits are routed through GSFC, which is the switching center for circuits used in support of earth satellites.

1.1 TELETYPE SWITCHING SYSTEM

The teletype switching system to be utilized for Nimbus is a Univac 490 solid-state communications processor (CP) which was installed to replace the manual and semi-automatic switching systems. Figure

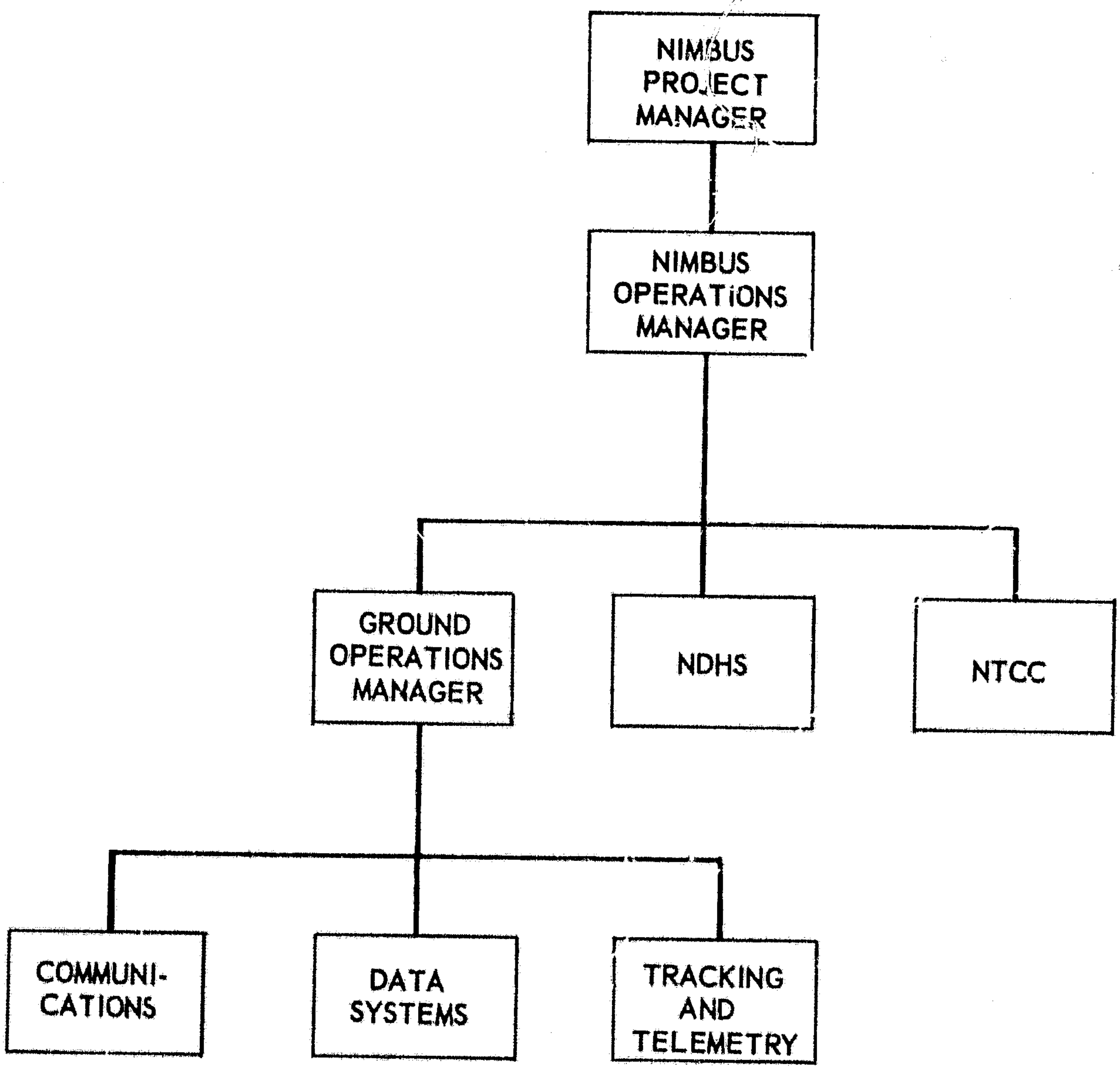


Figure IV-1 – Nimbus Operations Organization

IV-2 is a block diagram of the 490 system, consisting of duel CP's with associated units. During mission operations, each incoming teletype signal is connected to the input of both CP's simultaneously but independently. The output of one CP is connected to the outgoing line and the other is inhibited. If the active or operational unit fails, all output channels are transferred to the standby unit without loss of traffic.

The CP is a real-time processor designed for switching teletype and digital-data messages. Each CP contains 16,384-word core storage with an access time of 1.9 microseconds. Each word consists of 30 bits. Sixty-two basic instructions are provided and can be modified to produce over 25,000 different instructions. The average execution time is 12 microseconds.

Each CP utilizes an FH 880 drum with a storage capacity of 3,932,160 characters with an average access time of 17 milliseconds.

The Uniservo III-C mangetic-tape units provided with the system have a storage capacity of 2.8 million teletype characters per magnetic tape. Maximum access time to a message stored on tape is 3.5 minutes.

Some of the features of the 490 system are:

- Immediate cross-office transfer from input to output as messages are received. This transfer is at a rate of 150,000 characters per second rather than at teletype speeds.
- Utilization of magnetic tape instead of paper tape for temporary and/or permanent storage of messages.
- Automatic speed conversion to allow transmission from 100-word-per-minute circuits to 60-word-per-minute circuits, etc.
- Internal timing of messages, so that when a message is received in the CP, it is automatically annotated with a time of receipt in hours and minutes. When a message is transmitted, it is annotated with a time of transmission and reason for any delay. The annotation is for internal use in the CP and does not appear on any message.

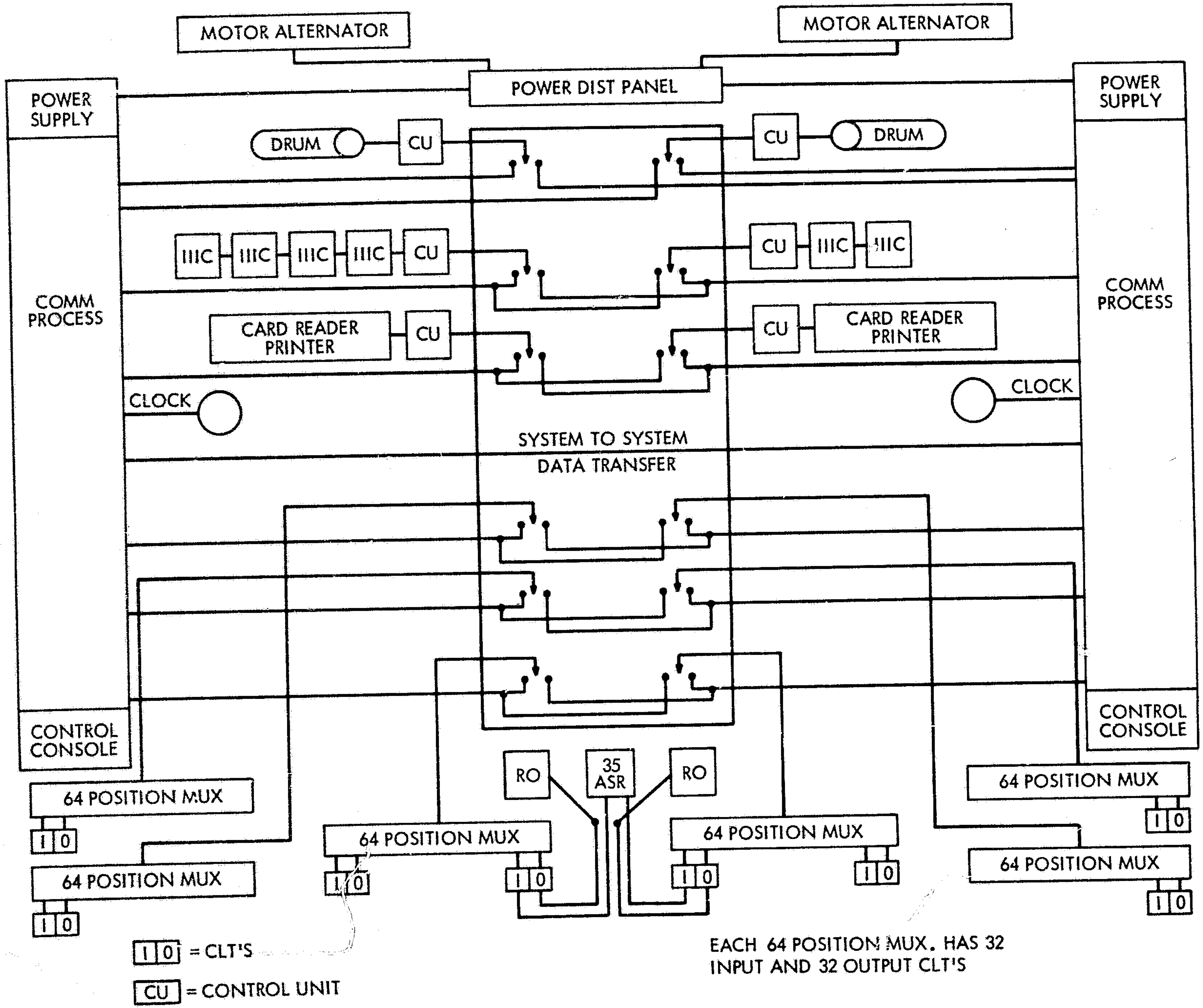


Figure IV-2 – Univac 490, Block Diagram

- Multiple-address messages are sent to the station as soon as each individual channel becomes available: If a multiple-address message is addressed to 10 stations, and all circuits are available, all 10 stations will receive the message simultaneously.

1.2 MESSAGE PREPARATION

All operations via the CP necessitate the use of normal message formulation as specified in NASCOP.

1.3 TRANSMISSION METHODS

The speed of operation and methods utilized by the CP to send traffic allows each transmitting station, by the use of collective routing indicators, to broadcast his message to a preselected listing of stations. The collective indicator for the STADAN stations will be promulgated by message. The use of this indicator will automatically send a message to STADAN.

If it is desired to send a message to other locations, as well as those included in the collective indicator, the routing indicators of those stations must appear in the routing line.

1.4 NETWORK ISOLATION

Network isolation provides a method to ensure that non-mission-oriented traffic cannot interrupt or be received by a station that is in a mission mode of operation.

Network isolation is accomplished by a program routine to provide, under control of the CP control console (CPCC), the capability to protect selected stations from non-mission-oriented messages. Message selection to isolated stations is handled by the CP on a precedence selection basis. When stations are in a mission mode, the only messages the CP will allow through are those containing a precedence level of UU, SS, or NN, as defined in paragraph 1.5 below. Messages received in the CP with a precedence level of PP or RR are stored on a queue for transmission to the stations upon instructions from the CPCC. An advisory is also printed out at the CP intercpet/advisory area to indicate that such traffic is waiting transmission.

Stations within an isolated grouping may, if allowed under the mission traffic rules listed below, send messages with a normal nonmission precedence to any station that is NOT in the isolated grouping.

1.5 MISSION TRAFFIC RULES

When directed by NETCON at approximately T-60 minutes, all participating stations will observe the following rules:

- Only specific mission-oriented messages will be transmitted.
- The basic message format, shown below, will be primarily used during mission periods.
- All messages will be as brief as possible consistent with clarity.
- Non-mission-oriented traffic will be allowed only by special direction.
- Individual message receipts will not be sent unless dictated by message precedence or originator.
- Self-addressed number comps will be utilized if no traffic is received for a period not to exceed 10 minutes.
- GSPA-originated (Greenbelt, Operations Area) teletype circuit checks will be answered immediately upon receipt.
- Mission precedence will be used on all messages concerning the mission.

  UU - As defined in NASCOP

  SS - Pass acquisition reports, quick-look reports, etc.

  NN - Preliminary orbital elements, requests for general information concerning launched satellite that does not interfere with stations operational responsibilities, etc.

1.6 PRELAUNCH OPERATIONS

1.6.1 NETWORK ISOLATION

All participating stations will be placed in network isolation at approximately T-60 minutes. At this time, mission traffic rules will be implemented by message from GSPA.

1.6.2 COMMUNICATION CHECKS
Periodically, communications checkouts will be held, GSPA will initiate collective circuit checks. All stations will answer immediately.

1.6.3 READINESS REPORTS TO NETCON
Approximately T-120 minutes and again at approximately T-60 minutes, all participating stations are to submit a readiness report upon notification from NETCON with an NN precedence. This signifies the station status.

1.7 LAUNCH OPERATIONS
See Mission Traffic Rules, paragraph 1.5 above.

1.8 POSTLAUNCH OPERATIONS
GSPA will advise at approximately T+90 to 120 minutes that all stations are returning to normal circuit. Even though network isolation has been terminated, stations will continue to utilize mission precedence levels until otherwise notified by GOPS (normally, until a firm orbit is obtained). NETCON's normal teletype routing indicator is GNET. This will be used on all teletype traffic addressed to NETCON except during launch and early orbit phases. During the launch and early orbit phase, all operational traffic will be sent to NETCON using the special teletype routing indicator, GOPS. At the end of the launch and early orbit phase (NETCON will direct) all traffic will be sent to NETCON using the GNET indicator.

1.9 SAMPLE MESSAGES

- Basic message:

  WNK014A
  SS GOPS
  DE LWNK 022
  01/2345Z
  (2CR 2LF)
  ....TEXT
  (2CR 2LF)
  01/2355Z FEB LWNK

- Basic message using a collective routing indicator and including other stations that must receive the message:

  NN DSD____JRGO
  DE GOPS 013

01/2355Z
(2CR 2LF)
....TEXT
(2CR 2LF)
01/2359Z FEB GOPS

Note: Stations will NOT utilize the collective indicator unless authorized to do so by GNET.

- Teletype circuit checks:

1 GSPA to STATION
NN DSD___(or a specific station)
DE GSPA 074S

CKT
TELETYPE CIRCUIT CHECK
01/1815Z1 FEB GSPA

2 Reply by station:

WNK017S
NN GSPA (Note: reply is addressed to GSPA
Not to DSD____)
DE LWNK 036

CKT
TELETYPE CIRCUIT CHECK RECEIVED
01/1819Z FEB LWNK

Note: The standard reply of "teletype circuit check received" indicates the circuit was received without error. Otherwise, an evaluation will be included in the reply, e.g., "Teletype circuit check received with 10 errors," etc.

CKT replies will be answered on all circuits on which received unless the CKT specifically requests an answer on one designated circuit.

1.10 COMMUNICATIONS WITH SUPPORTING STATIONS
Data received from Pretoria will be transmitted to GSFC via the Mission Control Center, Cape Kennedy, on teletype circuit 7005-15. PMR data from San Nicolas Island and Point Arguello will be sent over the Point Mugu teletype line.

1.11 HIGH-SPEED DATA TRANSFER (DIGITRONICS)

High-speed transmission of teletype data is basically an extension of voice circuits on a voice/data alternate transfer system. Circuits normally terminated on the Switching Conferencing and Monitoring Arrangement (SCAMA) facility are switched in the same manner for voice or data transfer. The effect of this system is to provide a rapid exchange of tracking data between the CDC 160 (GPUT) area and the sites. Present plans provide for a magnetic tape transfer of data from GPUT to the Digitronics area and, for certain remote stations, a magnetic-tape-to-magnetic-tape transfer.

The equipment configuration generally consists of a Digitronics D505 paper-tape transceiver. Some locations have on-line page printers and magnetic-tape (D520) transceivers. The tape system is generally limited in speed of operation to approximately 1000 wpm in the outward direction (toward the sites), and approximately 1,500 to 2,000 wpm inward. The speed of magnetic tape transmission is limited by the characteristics of the circuit and the number of data subsets available for use on voice-grade circuits. The system provides for error detection and correction and editing features. The major use of the Digitronics high-speed transmission system is for the extremely long station predictions, topocentric data, etc.

1.12 SWITCHING, CONFERENCING, AND MONITORING ARRANGEMENT (SCAMA)

The NASCOM network circuits are centered on SCAMA at GSFC. Facsimile/voice/data communications loops can be established in the SCAMA network as follows:

GILMOR
GSFC NDHS
ROSMAN
NTCC
NETCON
JOBURG
Point Arguello - (PMR Mission Director Center)

SCAMA will be the central control point for these circuits and will have the capability for connecting any stations point-to-point or in conference as desired.

1.13 DIGITAL DATA TRANSMISSION SUBSYSTEM

The digital data transmission subsystem consists of a magnetic tape transport including read and write circuits, a 1024-character magnetic core buffer memory, a control unit, and a control panel.

The data handled will be telemetry information received from the Nimbus spacecraft, processed at the GILMOR station, and transmitted to the GSFC NDHS via the digital data transmission subsystem. The data received from the magnetic tape are checked for character and longitudinal parity. If an error is detected in the block, the control unit will attempt to read and retransmit the data again. If the data cannot be read after four such attempts, an input error will be indicated on the control panel. After noting the indicated error the transmit operator can either force the unit to read the bad block or pass over it. If the block is forced, the error and the block are flagged by insertion of Octal 77's. A block or record length must always be processed to read 1024 characters. A block of characters less than this amount will cause tape check error indication and immediate disconnect (stopping transmission) at the transmitting equipment and a line check and a disconnect after a 5-second interval at the receiving equipment. The operator at the transmit equipment may either force the bad block or elect to pass over it and go on to the next block. If the bad block is forced, Octal 77's will be added to block, with the 1021st character being flagged with a forced block indicator. Should the block length be greater than 1024, a memory overflow indication will appear on the transmit unit and the equipment will disconnect; the receiver will disconnect 5 seconds later. The operator at the transmit equipment may force the long block or pass over it by depressing the read bad tape or forward one block buttons. If the bad block is forced, all characters after 1024 characters will be deleted and the block flagged as indicated for the forced transmission of the short block. Data are handled at the rate of 18,000 bits per second. As data are received at the receiving station they are stored in the 1024-character capacity buffer memory. After a complete block is accepted as being correct by the buffer memory, it is written on magnetic tape. Should an error be detected by the memory unit, the receive unit will request that the block be retransmitted. Four successive requests for retransmission may be made; if error is still detected, the receive unit will not write the block and both units will disconnect.

A voice circuit independent of the data link provides the facility for coordinating transmission information between operators.

1.14 X-108 OPERATION

The data transmission subsystem, X-108, provides the means of transmitting data received from the Nimbus spacecraft from the GILMOR DAF to GSFC and the National Weather Satellite Center (NWSC) at Suitland, Md. In the terminal equipment, redundant systems are provided in the north to south direction. These identical sets are designated systems 1 and 2. One receiving terminal is provided at GILMOR for reception of signals from GSFC. In addition, the PCM channel has a duplicate backup receiver. Where two systems are provided, a terminal can use either system at any time. Should trouble develop in the system in use, the other system can be immediately substituted by pushbutton control.

1.14.1 SYSTEM DESCRIPTION

The bandwidth required for transmission of data to GSFC is reduced by taking advantage of the period between interrogations and transmitting data to GSFC at a slower rate than it was received at the DAF. The temporary storage required for this mode of operation is included in the AVCS/HRIR ground subsystem and the computer subsystem.

The output of the X-108 is used to modulate a microwave carrier, which may be demodulated and remodulated up to 30 times at relay stations between the GILMOR DAF and GSFC. When fully operational, the transmission link will run from the DAF to GSFC and then to NWSC. In the southbound direction, the DAF can transmit to GSFC and NWSC or to GSFC only. This choice is under the control of NTCC.

In the northbound direction, the only transmitters connected to the lines are at GSFC with transmissions from NWSC being terminated at GSFC.

1.14.2 CIRCUITRY

The X-108 uses two groups of 48-kc bands in both directions at the standard groups frequencies of 60-kc to 108-kc. Both the groups are operated in two modes, designated as modes 1 and 2. The same mode is always used simultaneously on both groups. Provisions have been made for a mode 3, which will be used to send real-time PCM data and command verification to GSFC and real-time commands from GSFC to GILMOR.

Figure IV-3 shows the transmission arrangements for each mode. Mode switching and priority of data transmission are under NTCC control. Systems elements desiring use of any channels other than voice must coordinate their request with NTCC.

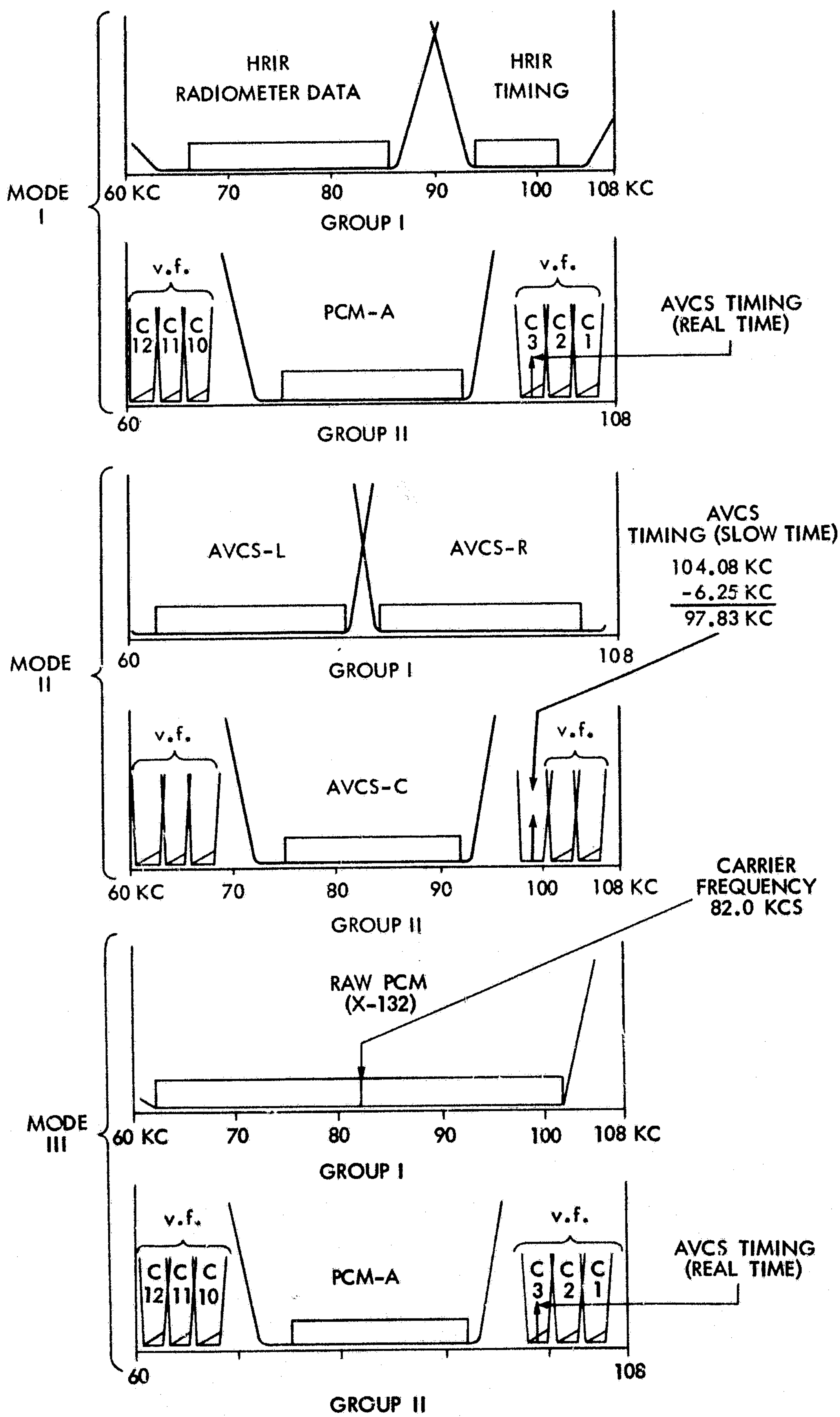


Figure IV-3 – X-108 Circuits

While the transmission of the information is north to south, the X-108 equipment provides transmission capabilities in both directions. The voice channels must, of course, work in both directions as well as the path for PCM telemetry data. Equipment for establishment of the other paths in the northbound direction is provided in order to permit loop back testing.

1.14.3 INFORMATION HANDLED

The information transmitted to GSFC consists of:

- HRIR - The HRIR video signal represents the cloud coverage on the dark side of the earth.

- HRIR Time Code - This signal represents the time at which the video data was collected and is transmitted simultaneously with the HRIR video signal.

- AVCS - Left, Center, and Right - The advanced video camera system video signal represents cloud coverages on the sunlit side of the earth as seen by the three cameras.

- AVCS Time Code - This signal represents the times at which the AVCS shutters were tripped. It is transmitted to GSFC twice; the first in real time as it is received from the satellite and again in slow time simultaneously with the transmission of the AVCS video signal.

- PCM - Digital data generated by the computer subsystem are transmitted to GSFC on a pulse-code-modulation basis via the digital data transmission subsystem.

- Voice - Six additional channels are provided between the DAF and GSFC for the transmission of voice signals, teletype signals, and other narrow bandwidth signals.

- PCM - Real-time data as received from the spacecraft to the GSFC NDHS.

- Command verification - Commands sent by GSFC will be verified by returning the command transmitter signal to GSFC for decoding and verification.

1.15 X-128 OPERATION

The X-128 data transmission system provides the means of transmitting data received from the Nimbus spacecraft from the ROSMAN DAF to the NDHS at the Goddard Space Flight Center.

1.15.1 SYSTEM DESCRIPTION

Telemetry data transmission is possible in the ROSMAN to GSFC direction only. Redundant terminal equipment is provided at both ends under pushbutton control for additional reliability and protection in the event of equipment malfunction or failure. All data are transmitted to GSFC in real time as received from the Nimbus spacecraft. Since the X-128 facility is used on a shared basis with projects OAO and OGO, mode switches are provided at ROSMAN and at GSFC to select the proper user; i.e., Nimbus, OGO, or OAO. A full-duplex command and command verification facility is also provided between GSFC and ROSMAN to permit real-time transfer of spacecraft commands from GSFC to ROSMAN with command data verification via the return side of the circuit. Backup or redundant terminal equipment for this circuit also exists, but must be patched up in the X-128 terminal equipment area. This circuit is also shared with OAO and OGO, but on a patching basis rather than with pushbuttons. Coaxial patchboards and monitor oscilloscopes are provided at ROSMAN and at Goddard for line monitor and test purposes.

1.15.2 CIRCUITRY

The X-128 system utilizes a basic 1-Mc leased microwave facility which employs about 20 radio repeating stations between ROSMAN and GSFC.

Two separate channels are derived from the 1-Mc baseband for telemetry remoting. The Nimbus composite channel (bandwidth 750 kc) handles the spacecraft composite S-band signal consisting of AVCS left, center, and right, AVCS real-time timing, two channels of HRIR, and two channels of HRIR timing. The PCM channel (bandwidth 50 kc) handles the spacecraft PCM signals consisting of either PCM-A real time, PCM-A stored, or PCM-B and spacecraft time code.

2. NIMBUS TECHNICAL CONTROL CENTER (NTCC)

The Nimbus Technical Control Center (NTCC) is the Nimbus project group responsible for the surveillance and control of the Nimbus spacecraft. NTCC is the focal point for all phases of Nimbus operations. This includes evaluation of spacecraft and NDHS ground equipment status, preparing spacecraft command sequences, determining emergency actions, providing long-range analyses of spacecraft performance,

providing data and reports to the Project Manager, and scheduling transmission of operational meteorological data to NWSC.

Prolonging the life of the batteries is the most important consideration in programming the spacecraft. Therefore, stored-A telemetry which offers the information required to know the status of the battery will be treated as the prime telemetry mode. The acquisition of telemetry data for the safety of the spacecraft will have priority over meteorological data.

2.1 NTCC FACILITIES

Under supervision of the Nimbus NTCC Manager, NTCC is manned by a team of system engineers and scientists. NTCC will provide a continuous 24-hour-a-day operation. Data display, equipment status, data evaluation, calculation, and communication facilities will be provided in NTCC. Portions of the GSFC NDHS will be used by NTCC for rapid data extraction and interpretation.

NTCC is located in Building 3 at GSFC, adjacent to the GSFC NDHS facility (Figure IV-4). Coordination will be maintained with the TIROS Technical Control Center to coordinate camera utilization of both systems. Communications between NTCC and other facilities of the Nimbus system are maintained by voice and teletype circuits and wideband data links. Voice communications between NTCC, GILMOR, ROSMAN, the GSFC NDHS, and PMR are provided via the SCAMA network. Teletype receiving equipment is located in NTCC for receiving spacecraft data and operational reports. Facilities for transmission of teletype messages are available in SOCC.

Wideband data links are provided for transmitting information from GILMOR and ROSMAN to the GSFC NDHS. GILMOR can transmit the following data via the wideband data link:

- Gridded and/or nongridded AVCS and HRIR pictures
- PCM data converted to engineering units and/or PCM volt units
- PCM real-time data and command verification
- Selected spacecraft attitude and meteorological data
- AVCS timing data in real time

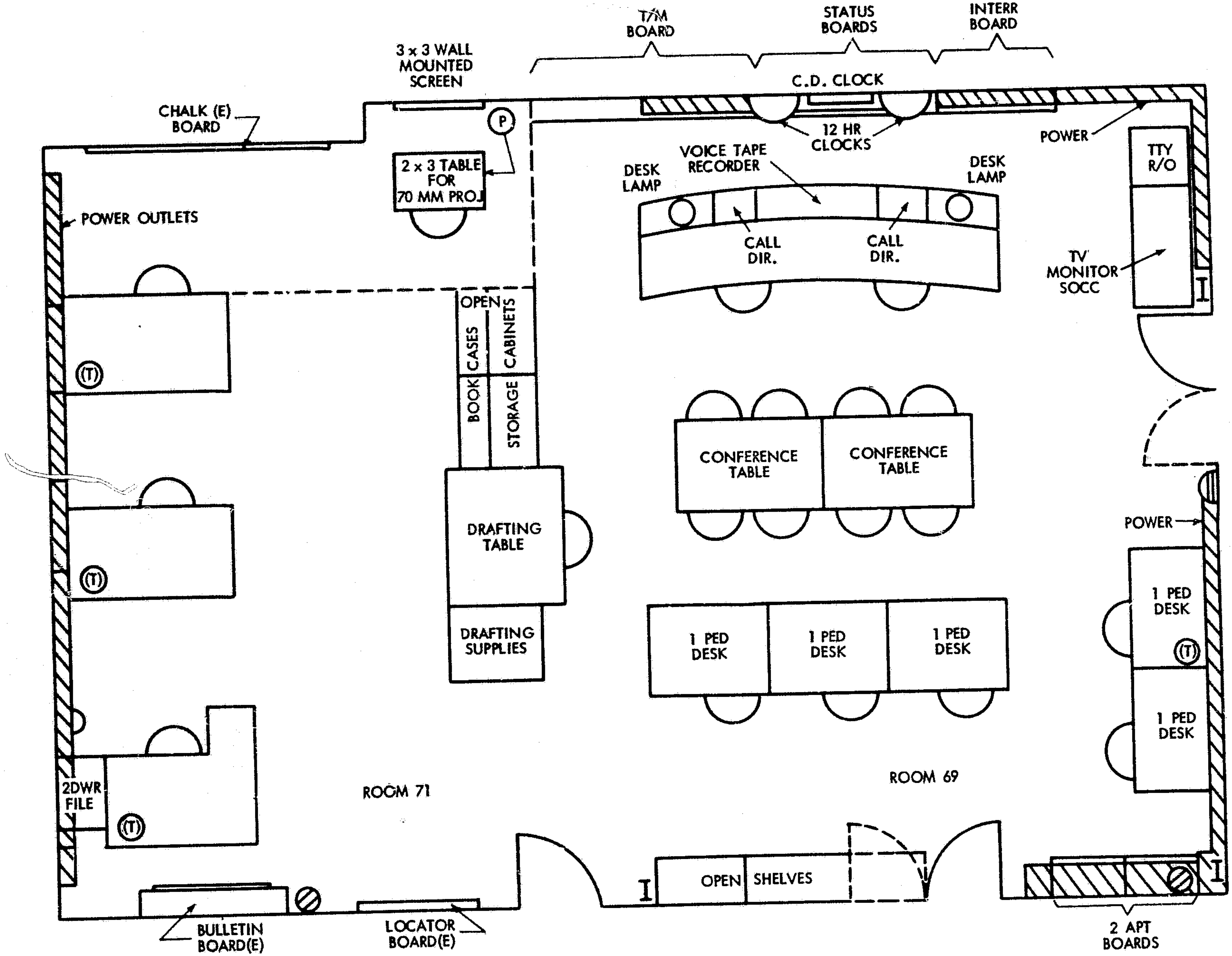


Figure IV-4 – NTCC Facility, Layout Diagram

Selection of the mode of data processing and priority of data transmission is a responsibility of NTCC. ROSMAN will transmit raw sensor and telemetry data in real time to the GSFC NDHS for processing. Selective data are processed at both NDHS facilities for NTCC operational and engineering evaluation.

2.2 DATA REQUIRED

To accomplish its mission, NTCC requires continuous spacecraft and ground equipment data as follows:

2.2.1 SPACECRAFT

- Launch countdown status and time, Agena B second ignition, pitchup, separation, solar paddle deployment, control system activation
- Predicted spacecraft position for at least one week in advance
- Spacecraft interrogation schedules
- Spacecraft time and Greenwich Mean Time
- Values of all spacecraft telemetered functions
- All operational modes

2.2.2 GROUND EQUIPMENT

- Daily status of all operational equipment and a status report about 15 minutes prior to each period of continuous support
- Received signal strengths to evaluate air-to-ground communication links
- Changes to equipment status or manning as they occur
- Status of wideband data links
- Schedule of all operational equipment support for a week in advance, including wideband data links, and changes as they occur
- Location of all APT ground stations

NTCC serves not only as a controlling facility, but also as a clearing house for all information where decisions will evolve from a carefully

planned process flow and will be converted into controls to make the overall Nimbus system function properly and smoothly. The NTCC activities are compatible with the operations and flow of information between the other Nimbus facilities and agencies.

The operations performed at NTCC relating to spacecraft assessment and ground complex equipment not only include evaluation on a short-term basis, but also evaluation of long-term status. Logs will be kept on a continuous basis. Several of these logs will then be compared to reveal trends in the performance of functions such as: solar paddle voltages, rate of control gas used, structural and component temperatures, or other measurements that would provide the NTCC staff with enough data to permit a prediction of spacecraft performance with far more accuracy than could be made from immediate telemetered data on a one-pass basis.

2.3 OPERATIONAL CONTROL

As standard operating policy, all operational activities of the Nimbus system, to include control of the spacecraft and priorities of data processing and transmissions, will at all times be under the direct control of NTCC. Any exception to this policy will be made in the form of a directive by the Nimbus Project Manager. In this role NTCC will:

- Originate weekly schedule which outlines orbits to be interrogated and the DAF stations responsible for the command and data acquisition, and arrange the scheduling of the DAF through NETCON and inform NDHS Managers of the approved schedule

- Place data processing requirements on NDHS within the limits of NDHS capabilities. Processing of data to support NTCC evaluation of spacecraft performance has priority over all other NDHS activities

- Be cognizant of ground equipment status at all times

- Maintain a history of spacecraft and ground equipment performance for use in operational performance assessment and engineering evaluations

- Perform engineering analyses and prepare engineering reports as directed by the NTCC Manager

- The Nimbus Operations Manager, in conjunction with the Spacecraft Systems Manager, is responsible for the remedial action to be taken in the event of abnormal conditions developing within the spacecraft. He will advise NTCC of the action to be taken.

2.4 PRELAUNCH ACTIVITIES

During the prelaunch phase NTCC will:

- Establish the interrogation schedule for the first week
- Perform prelaunch checks on all displays as required
- Prepare all worksheets, charts, graphs, etc., as required
- Institute dress rehearsals of the wideband data links with NDHS and NWSC
- Report the state of readiness of the NDHS to the Project Manager at PMR
- Insure that APT weekly messages are mailed to the APT stations beginning two weeks before launch

2.4.1 OPERATIONAL READINESS TESTS

The ground system complex will undergo a series of tests to check out the equipment and procedures. Approximately 20 minutes before an interrogation begins, a prepass readiness test will be performed. The prepass test will be a combination of go/no-go checks and alignments for setting of key elements of the system. A more extensive daily check-out will be performed to adjust these key elements.

2.5 LAUNCH ACTIVITIES

During the launch phase, NTCC will monitor launch operations and assure that responsible personnel are informed of spacecraft progress. During launch, NTCC will be in voice contact with the Nimbus Operations Manager at the GILMOR NDHS and the Project Manager at PMR. The information listed below is required by NTCC before the first interrogation at GILMOR to determine proper spacecraft command sequence and subsequent flight operation.

- Exact spacecraft launch figuration
- Time of last PCM tape recorder playback before launch

- Amount of calibration data remaining on the AVCS and HRIR tape recorders and the tape position on the recorders at launch

- Time of final spacecraft to internal power

- Time of liftoff

- Beacon operation and spacecraft time at separation (as reported from JOBURG)

- Spacecraft stabilization status (as reported from WNKFLD) during the first sun acquisition

2.6 POSTLAUNCH OPERATIONS

During the postlaunch phase, NTCC will:

- Determine which DAF station can acquire and interrogate the spacecraft for each orbit, and establish the interrogation schedule and coordinate with NETCON

- Calculate the expectant spacecraft power balance for each orbit

- Originate daily spacecraft command sequences, and determine necessary changes to same on an orbit-to-orbit basis

- Select and transmit courses of action to be taken by NDHS in emergency situations

- Monitor the spacecraft subsystems to determine operating trends and predict possible malfunctions

- Monitor ground equipment status and maintenance downtimes to know if the DAF stations will be prepared to acquire data from the spacecraft at the designated times

- Specify the sequence of daily data-handling operations of NDHS

- Schedule NDHS to provide meteorological data to NWSC

- Schedule Nimbus data transmission priorities over the wideband data links

- Evaluate spacecraft and Nimbus ground system performance

- Coordinate meteorological coverage with NWSC when there is a choice of data coverage

- Coordinate ground system testing

- Prepare and initiate outgoing teletype messages and receive a confirmation copy from NETCON

- Determine when the GILMOR APT station will operate

- Transmit Nimbus APT Daily Alert and Ephemeris Predictions and emergency messages for the APT stations

- Mail weekly messages to the APT stations

- Confirm transmission of orbital information to the CDC 924 computer complexes

- Operate all displays in NTCC

- Prepare routine and emergency reports

- Log all incoming and outgoing messages, reports, and requests

- Provide subsystem diagnostic data

- Provide latest PCM telemetry limit check and functionalization data to the CDC 924 computer systems

2.6.1 SPACECRAFT ACTIVATION

The initial activation phase is the period required to go from the launch and minimum spacecraft condition to full and routine spacecraft operation. During this phase, command response and subsystem operation will be tested under carefully controlled conditions. Performance will be verified with minimum risk to the power supply and the other subsystems. Scheduling of spacecraft loads and sensory subsystems will be from a spacecraft safety standpoint and will take precedence over obtaining continuous meteorological data. The initial activation phase will last from two to possibly four weeks, depending on the performance achieved and the level of confidence developed. Programmed spacecraft commands will be initiated by the NDHS stations as directed by NTCC. Responsibility for assuring the safety of the spacecraft during initial activation lies with the Nimbus Operations Manager and the

Spacecraft Systems Manager. Technical support will be provided by the Nimbus project, including the NTCC staff, the spacecraft subsystem technical officers, and the ground systems group. The exact sequences of the initial commands will depend on the results of environmental testing and whether stabilization is achieved during daylight in the first orbit. The command sequences during the first few days will also make maximum use of the ROSMAN DAF to fill gaps in the data acquisition at GILMOR.

During the activation phase, some of the specific tasks of NTCC will be:

- Update the spacecraft command sequence from information obtained from the launch phase

- Evaluate spacecraft telemetry to determine usability of all time slots, nominal operating values, threshold values, calibration, and limits

- Compare predicted power balance calculations with telemetered data and update calculations as required

- Determine attitude error and any correction required

- Evaluate calibration of sensory subsystems

- Update computer telemetry programs with latest data

- Evaluate data processing and handling to determine best techniques to process all spacecraft data between interrogations

- Coordinate APT camera operation with the APT ground stations. The APT camera may be cycled on and off to conserve power during many of the early orbits.

2.6.1.1 <u>Operational Considerations</u>

The initial activation program is intended to provide the maximum safety to the spacecraft. Some of the considerations and the procedures applied are as follows:

a. On-pass decisions pertaining to load scheduling of the spacecraft will not be exercised except to prevent catastrophic failure of the spacecraft or possibly when the batteries go into a partial failure mode. When on-pass decisions are made, they will be according to a precalculated battery load schedule that puts the batteries closer to the optimum operating

zone even after evidence of trouble, prompting the on-pass decision, proved to be misleading.

b. There is a possibility of the prelaunch status of the command relays being changed during the launch operation. The pertinent functions should be re-commanded to their proper status during the first interrogation.

c. In view of the inexperience in tracking and actual commanding of the spacecraft, the early interrogations will be planned to be as simple as possible and to take less time than the predicted acquisition time duration.

d. The first command issued during a pass and after any "stop" code on the command tape will be sent twice on separate memory locations to avoid the possibility of faulty transmission.

e. Prolonging the life of the batteries is the most important consideration in programming the spacecraft. Therefore, stored-A telemetry which offers the information required to know the status of the battery will be treated as the prime telemetry mode. The acquisition of telemetry data for the safety of the spacecraft will have priority over meteorological data.

f. The requirements for prolonging the life of the batteries and for protecting the safety of the spacecraft take precedence over delivering continuous meteorological data.

g. If the RF-link proves to be satisfactory, real-time-A telemetry will be used to convey real-time confirmation of command execution.

h. In view of the fact that the effect on solar array output is not very severe for yaw errors that might be due to launching at the extreme of the launch window, no fine yaw corrections will be attempted during the early interrogation. This will allow time to make sure the yaw attitude has settled down and the data are reliable (also applies to orbit errors caused by the gyro or yaw control loop in general).

i. The necessity for yaw bias correction due to improper plane inclinations is anticipated to be a very long term consideration— no sooner than a month after launch.

j. To offer maximum safety wherever possible, back-up commands that are redundant to automatically switched functions will be issued. The activation sequence will be designed to develop confidence in the automatic functions.

k. Since there will be no previous experience with a realistic orbital thermal pattern for the spacecraft, no decision on applying loads from a thermal consideration will be made until at least the third interrogation.

l. Redundant telemetry points, previous data, or available alternate techniques of verification should be used to establish confidence in the telemetry functions and to confirm indications of problems existing or developing.

m. Until the spacecraft reliability is established (by spacecraft manager) APT and AVCS subsystems will be turned off during blind orbits to avoid catastrophic spacecraft failure resulting from the day-night relay hanging up in the day position.

n. After gaining system operation experience with full daytime operation of APT, it should be scheduled to operate only during parts of day orbits falling within APT ground station range to prolong its life, providing it is compatible with the solar power system requirements.

o. The programs herein recommended for each orbit are predicated on a favorable temperature and battery status existing. They are subject to change depending on the information acquired during the previous two interrogations. Loads might have to be added or removed to change the battery charge status from one level to another, or to maintain the battery charge level constant at the end of the orbit.

p. The activation sequence proposed applies to any type of orbit that Nimbus is placed in. It is anticipated that even in the absence of the launch vehicle second-stage burn and the resulting elliptical orbit, the life of Nimbus could be several days before the thermal buildup at the perigee would become

destructive. Since all subsystems are scheduled to be turned on well before the 14th orbit, no special programs for elliptical orbits are required. However, if a faulty orbit is achieved, it would probably develop that deviation from the proposed sequences will be necessary to maintain the proper power balance.

q. Precise time coincidence of the spacecraft clock and ground time is not considered essential. Although the clock will be reset precisely during certain interrogations, the rule to be applied is to reset the clock to the anticipated interrogation time if the error exceeds 10 seconds. This will allow setting a predetermined time into the clock which can be done quickly—in seconds compared to 1/2 to 2 minutes—and allow tapes to be made with stored commands without taking up too much of the interrogation time available to set the clock.

r. Where a potential problem can be anticipated, the use of the unencoded commands will be included in the recommended command sequences. However, in the main, the unencoded commands and their related coded commands will have to be issued judiciously when an on-pass situation warrants emergency action.

s. The purely redundant functions such as alternate power supplies, D/N relays, and cosine pots, will not be tried until a failure mode occurs with the prime function. This will minimize the possibility of having component failures causing premature catastrophic spacecraft failures in the process of merely verifying that both redundant functions are operative.

t. The redundant iris drive motors will be alternated after initial activation approximately every day. This will minimize the possibility of mechanical seizure developing due to prolonged inoperation in vacuum and thereby inducing failure.

u. All command sequences, including alternative sequences and clock resetting, when possible, will be on a command tape for automatic command execution.

v. As a general rule to be followed for at least the first two weeks, before issuing command 224, S-band power on, issue command 032 AVCS recorder record and a stored command

032 to be executed at the appropriate time after S-band transmit is executed. See specific command sequence for each interrogation for this time delay. If memory locations are available, then an additional stored 032 command can be issued as an additional safety measure at the place indicated in these procedures.

w. No commands should be issued during stored-A PCM playback whenever the interrogation time available permits.

x. No clock reset operations should be planned during stored-A playback.

y. The S-band warmup or transmit commands should not be issued during the stored-A playback cycle.

2.6.1.2 Summary of Activation Plan

A summary of the spacecraft activation plan follows. Figure IV-5 shows station acquisition for the first 14 orbits.

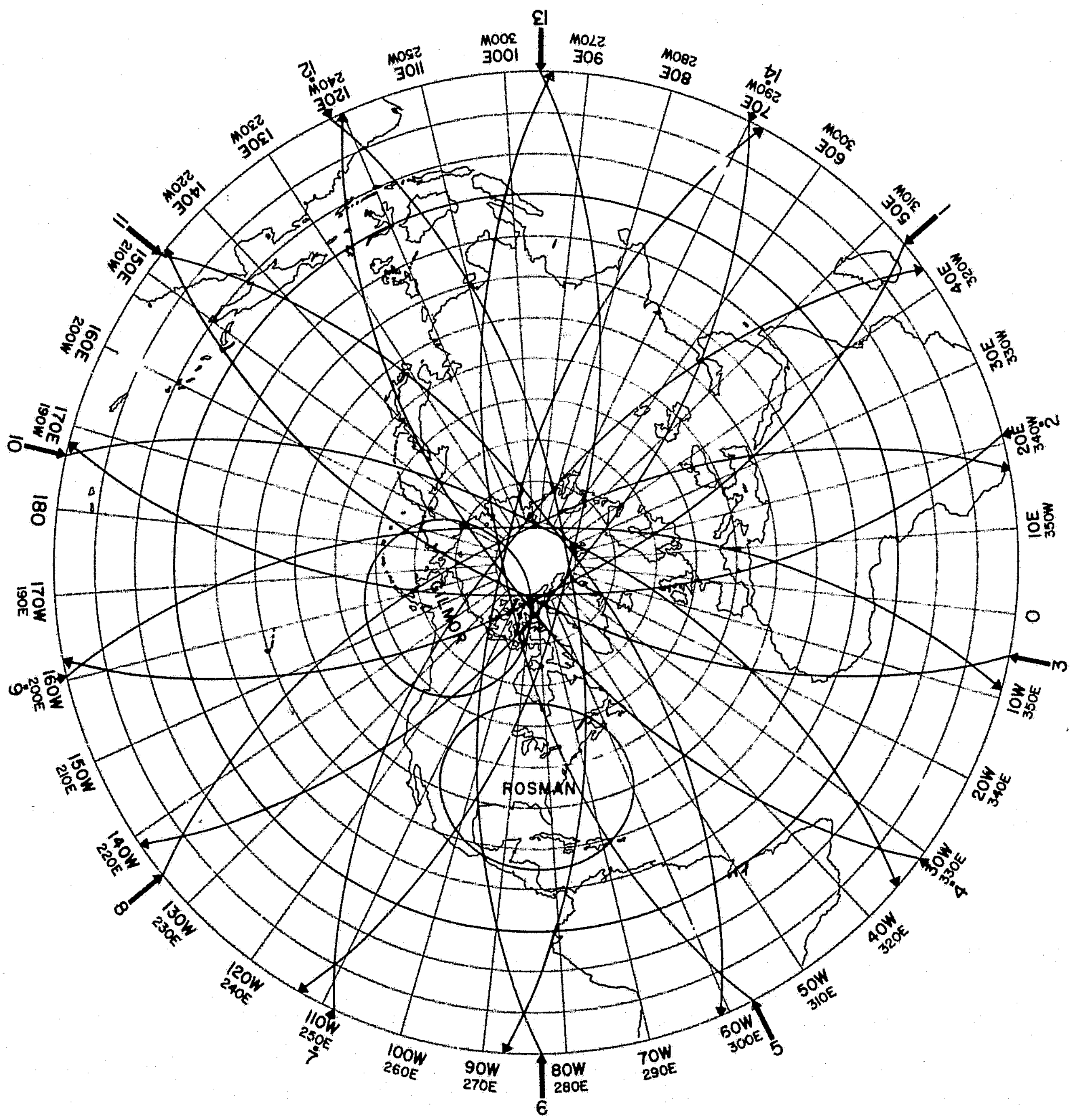


Figure IV-5 – Subsatellite Track for First 14 Orbits, showing 10° Elevation Circles at GILMOR and ROSMAN

SPACECRAFT ACTIVATION PLAN

Command Sequence

Interrogation No.	1	2	3	4	5	6	7	8	9	10
Orbit No. G.GILMOR R.ROSMAN	1G	2G	3G	4G	5R	5G	6R	6G	7G	8G
Reset clock to approx. time	1	2	2	1		1	1	1	1	1
Reset clock accurately										
Stored-A telemetry	2	1	1	6		6		2		2
B Telemetry		4			4					
Real-time A	4	5	4	2-7	1	2	2	3	2	3
Command aux. and comp. loads	3	3	3	3	2	3	3			4
AVCS direct picture							5	6		
AVCS on part time								8	8	
AVCS on full day										
HRIR on night				4		7		9	7	
HRIR on day										
IRSA on day						8				
IRSA on night										
S-band transmit carrier			5	5	5			4	3	
S-band transmit HRIR					6	4	6	5	4	5
S-band transmit AVCS					7	4			5	6
APT on part time					3	5	4	7	6	
APT on full day										

Type of orbital load	1	2	3	4	5	6	7	8	9	10
Partial sensors				X	X	X	X	X	X	
Full sensors										
Special aux. and comp.	X	X	X							X
Blind orbit coast-thru										

SPACECRAFT ACTIVATION PLAN (Continued)

Command Sequence

Interrogation No.	11	12	13	14	15	16	17	18	19	20
Orbit No. G.GILMOR R.ROSMAN	9G	12R	13R	14G	15G	16G	17G	18G	19R	19G
Reset clock to approx. time						1	1	1		1
Reset clock accurately					1					
Stored-A telemetry	1	1	1	1	6	6	2	2	4	2
B Telemetry					7					
Real-time A	3	2	2	3	2	2-9	5	5	1	5
Command aux. and comp. loads	2			2	3	3	6			
AVCS direct picture										
AVCS on part time					3		8			
AVCS on full day								8		8
HRIR on night						8	9	7		7
HRIR on day					5					
IRSA on day										
IRSA on night										
S-band transmit carrier										
S-band transmit HRIR						4	3	3	2	3
S-band transmit AVCS						5	4	4	3	4
APT on part time					4	7	7			
APT on full day								6		6
Type of orbital load										
Partial sensors					X	X	X			
Full sensors								X	X	X
Special aux. and comp.				X						
Blind orbit coast-thru	X	X	X							

SPACECRAFT ACTIVATION PLAN (Continued)

Command Sequence

Interrogation No.	21	22	23	24	25	26	27	28	29	30
Orbit No. G.GILMOR R.ROSMAN	20R	20G	21G	22G	23G	26R	27R	28G	29G	30G
Reset clock to approx. time		1	1						1	1
Reset clock accurately										
Stored-A telemetry		2	2	1	1	1	1	1	2	2
Real-time A	1	6	5	3	1	2	2	3	4	5
Command aux. and comp. loads			6	2				2		
AVCS direct picture										
AVCS on part time										
AVCS on full day		7							5	6
HRIR on night									6	7
HRIR on day										
IRSA on day		9								
IRSA on night		8								
S-band transmit carrier										
S-band transmit HRIR		3	3						3	3
S-band transmit AVCS		4	4							4
APT on part time										
APT on full day		5							7	8
Type of orbital load										
Partial sensors										
Full sensors	X	X							X	X
Special aux. and comp.			X					X		
Blind orbit coast-thru				X	X	X	X			

SPACECRAFT ACTIVATION PLAN (Continued)

Command Sequence

Interrogation No.	31	32	33	34	35	36	37	38	39	40
Orbit No. G.GILMOR R.ROSMAN	31G	32G	33R	33G	34R	34G	35G	36G	40R	41R
Reset clock to approx. time	1	1	1	1		1	1			
Reset clock accurately										
Stored-A telemetry	2	2		2		2	2	1	1	1
B Telemetry										
Real-time A	5	5	2	3	1	6	5	3	2	2
Command aux. and comp. loads							6	2		
AVCS direct picture										
AVCS on part time										
AVCS on full day	6	6		4		7				
HRIR on night	7	7		5		9				
HRIR on day		8								
IRSA on day										
IRSA on night										
S-band transmit carrier										
S-band transmit HRIR	3	3	3			3	3			
S-band transmit AVCS	4	4	4			4	4			
APT on part time				6						
APT on full day	8	9				5				

Type of orbital load										
Partial sensors										
Full sensors	X	X	X	X	X	X				
Special aux. and comp.							X			
Blind orbit coast-thru								X	X	X

2.6.2 INITIAL SPACECRAFT MANAGEMENT

In order to provide maximum protection for flight operations and to allow for the limitations of the wideband link, primary initial spacecraft assessment activity will be centered at the GILMOR DAF. A full system analysis capability will therefore be required at GILMOR for the immediate postlaunch period (Table IV-1). A second team will be required at GSFC to handle the ROSMAN data as well as to provide support to NTCC. In all cases, conclusions and courses of action will be discussed with and approved by NTCC prior to implementation. As soon as the spacecraft and ground operations are defined and stabilized, the center of spacecraft analysis and assessment will be moved to GSFC NTCC.

2.6.3 OPERATIONAL SPACECRAFT DATA HANDLING

Details of operational, routine data-handling procedures are given in Part IV, Section 4 of this plan, Nimbus Data-Handling System. Some of the NTCC-NDHS operational interfaces are described below.

The GILMOR Data Operations Supervisor will coordinate the routine data-handling activities between GILMOR NDHS and GSFC NDHS after a GILMOR acquisition. Coordination of data-handling activities between GSFC NDHS and ROSMAN DAF during a ROSMAN acquisition will be done by the GSFC NDHS Data Operations Supervisor.

The implementation of the preventive maintenance schedule for NDHS equipment will be the responsibility of the Data Operations Supervisor. The Data Operations Supervisor will immediately inform NTCC of all equipment malfunctions and equipment recovery times. A failure report will be completed by the operator team and a copy sent to NTCC whenever a failure occurs. This report will be used for evaluation of data and for reliability studies. The individual NDHS facilities are responsible for evaluation, operation, and maintenance of their equipment.

2.6.3.1 <u>NTCC Inputs to NDHS</u>

NTCC will provide NDHS with command lists for each spacecraft interrogation and requirements for data processing. The command lists will contain all commands to be sent to the spacecraft during each interrogation. Command lists will be given to GSFC NDHS and transmitted to GILMOR on a daily basis. However, NTCC may direct changes to these command lists based on between-orbits analyses of spacecraft performance.

Data processing requirements placed by NTCC on each NDHS in the operational situation may include such items as changes to the sequence of data handling or paper tape input modifications to the computer programs. Requirements for temporary modifications to NDHS data

Table IV-1

NASA Personnel Assignments for the Launch Phase

PERSONNEL	R-2 to R+10	+10 to +30
R. Shapiro	GILMOR	GSFC
B. Trudell	GSFC	GSFC
D. Beiber	*GSFC	GILMOR
J. Strong		GSFC
G. Burdett	GILMOR	GSFC
C. Bolton	GILMOR	GSFC
C. MacKenzie		GSFC
E. Moses	GSFC	GSFC
B. Schlachman	GILMOR	GSFC
J. Over	GSFC	
E. Greene	GILMOR	GSFC
M. Maxwell	GSFC	
P. Hui	GILMOR	GILMOR
W. Redisch	GSFC	GSFC
L. Foshee	*GSFC	GSFC
J. Lovelace	GSFC	GSFC
R. Stampfl	GILMOR	
F. Humphrey	GILMOR	
F. Logan	ROSMAN	
C. Maskaleris	GSFC	GSFC
A. Cunningham	GSFC	GSFC

*To depart from PMR immediately after launch.

processing based on between-orbit or on-pass evaluation of spacecraft performance data can be established by the NTCC systems engineer and transmitted directly to the NDHS Data Operations Supervisor on duty at the time. Modifications which require reprogramming or long lead time equipment reconfigurations must be coordinated through the NTCC Manager.

2.6.3.2 Pre-Pass Interfaces

The NTCC systems engineer will contact the NDHS Data Operations Supervisors via SCAMA voice link prior to spacecraft acquisition to inform him of the predicted spacecraft status expected during the pass. This prediction will be based upon all information available in NTCC, such as trends, orbital predictions, data-collection requirements, power balance and spacecraft loading calculations, spacecraft thermal status, spacecraft subsystem and component status, etc.

After performing pre-pass checkout, NDHS Data Operations Supervisors will report equipment readiness to NTCC. Selection of the most appropriate method of data handling will be made by NTCC.

2.6.3.3 On-Pass Interfaces

NTCC will monitor the NDHS communications net during spacecraft interrogations and will inform NDHS when it comes on and leaves the net.

During spacecraft interrogations, NDHS will report to NTCC any deviation from the predicted spacecraft status as indicated by computer printouts, PCM brush recordings, and AVCS/HRIR and APT video outputs.

Based on the on-pass assessment of the spacecraft status, all emergency spacecraft commands will be delivered by NTCC to NDHS via voice.

2.6.3.4 Post-Pass Interfaces

Immediately after the pass, NTCC will transmit off-line data-processing requirements to the NDHS Data Operations Supervisors. Selective AVCS and HRIR filmstrips and the off-line PCM program printouts will be supplied to NTCC for operational and engineering evaluation.

If, during the pass, the NTCC directed the NDHS to execute emergency command action(s), a confirmation teletype message will be initiated by NTCC and transmitted to the interrogating NDHS.

3. SPACE OPERATIONS CONTROL CENTER (SOCC)

The Tracking and Data Systems (T&DS) Directorate, Network Engineering and Operations (NE&O) Division is responsible for operation of the STADAN facilities used in support of Nimbus. The Space Operations Control Center (SOCC), located in Room 153 of GSFC Building 3, will be used in conjunction with NTCC to monitor the launch operations and

report on station status. The T&DS Operations Director in SOCC is H. Hoff/A. Ferris, a member of NE&O Division. In addition, SOCC will be used as the network control area for scheduling and control of STADAN operations at all times during the life of the spacecraft. All Nimbus project requirements for the use of STADAN will be integrated into the GSFC master schedule by the NE&O Division, Network Operations Branch, Network Control Section (NETCON), using the priority listing established by the Assistant Director, SS&SA, and the Assistant Director, T&DS.

The NE&O organizations that will support SOCC include the Network Operations Branch, the Spaceflight Branch, and Control Center Branch, as described below.

3.1 PRELAUNCH PHASE

3.1.1 NETWORK OPERATIONS BRANCH

To ensure that STADAN stations are fully prepared to support the Nimbus project, the Network Control Section (NETCON) of the Network Operations Branch will have the following duties:

- Check with the GSFC Data Systems Division to ensure delivery of predictions to STADAN and NTCC.
- Notify the GSFC switchboard at T-1 day of telephone service needed during launch.
- Confirm the nominal launch date and time to STADAN at T-10 days and also inform NORAD, Space Surveillance, Smithsonian Astrophysical Observatory, and Space Track so that outside agency early-orbit tracking support will be prepared. Followup notices of launch date changes will be made as required.
- Schedule all possible STADAN stations to monitor for the Nimbus spacecraft signal, using the nominal predictions.
- Give the Ground Operations Manager the readiness reports for the STADAN stations at T-120 and T-60 minutes for relay to NTCC and to the Project Manager at PMR. Immediate notification will be given if the state of readiness should change after T-60 minutes.

- Assist in establishing the phone circuits used for launch in the period starting at T-60 minutes

- Prepare and operate displays to be used for launch operations.

    1. STADAN acquisition schedule
    2. STADAN status
    3. Vehicle and orbital parameters

- Keep the Ground Operations Manager fully informed of the ability of GILMOR and ROSMAN to support the Nimbus project at all times starting at T-2 months. Reports will include all station outages, station's estimate of down time, and action being taken.

3.1.2 SPACEFLIGHT BRANCH

The Ground Operations Manager is the member of the Spaceflight Branch who will work with the Tracking and Data-Acquisition Systems Manager to ensure that all the assigned responsibilities of the NE&O Division in support of project Nimbus are completed and that the facilities are in a state of readiness.

He will have duties as follows:

- Prepare the flyby Ground Stations System Test Plan

- Participate in prelaunch readiness tests performed by the data-acquisition and data-handling stations

- Coordinate prelaunch training and readiness of DAF stations in conjunction with total ground systems operations

- Ensure that DAF facilities are technically prepared and staffed to support Nimbus operations starting at T-2 months

- Submit an access list for SOCC and the computer area for the launch operations

- Verify that the Nimbus A Mission Operations Plan and station acquisition predictions have been distributed to the ground support elements and that these elements are aware of their assigned responsibilities.

3.1.3 CONTROL CENTER BRANCH

The Display Manager, from the Control Center Branch, will have the following responsibilities:

- Prepare slides for the NTCC iconorama projector as required (to continue for the Nimbus lifetime)
- Coordinate the transmission of Doppler data from PMR for display by the SOCC iconorama projection system starting at T-0
- Arrange, in conjunction with the Ground Operations Manager, for the use of the auditorium in GSFC Building 3 for observers
- Install two video receivers in the auditorium and send the SOCC display information to these receivers during launch
- Arrange for the transmission of color TV information to NASA Headquarters and send this information as required
- Coordinate the flow of data from the real-time computers to display the gamma vs. v/vr and altitude vs. distance information
- Operate the iconorama and TV display equipment

3.1.4 TELEPHONE COMMUNICATION

Telephone communication for liaison, coordination, and/or data collection will be established as outlined below:

- SOCC SCAMA 24 will be conferenced to the PMR MDC, NTCC, GSFC NDHS, ROSMAN, JOBURG, and GILMOR. This phone conference will be used to keep all parties aware of the launch progress and to keep the Project Manager informed of the readiness of STADAN and the NDHS's. The project will provide talkers in MDC and NTCC and the Spaceflight Branch will provide a talker in SOCC. All other stations will monitor except when absolutely necessary to speak or when requested to give information
- SOCC "B" to MDC will be activated to allow the Project Liaison Officer, J. Townsend, to talk to the Project Manager
- SOCC "E" to the STADAN station at WNKFLD to get the spacecraft spin rate as it passes on orbit 1

- SOCC "D" to MDC will be activated to allow the Project Coordinator, A. Fihelly, to talk to the Project Manager

- SOCC "G" to NASA Headquarters mission status room will be used to keep NASA Headquarters fully informed of the progress and status of the launch and early orbit operations at all times

- SOCC "H" to NASA Headquarters press room will be used by the GSFC Public Information Officer to inform the NASA Headquarters Public Information Officer about the launch progress

- SOCC SCAMA 25 will be conferenced to PMR, GILMOR, and GSFC NDHS for technical discussions concerning NDHS equipment and the spacecraft

3.1.5 TELETYPE COMMUNICATIONS

The PMR MDC will teletype launch progress to SOCC (teletype code GNET) for relay to stations participating in the prelaunch and launch phases of the mission.

The NETCON working out of SOCC will control the network isolation grouping made up of ROSMAN, GILMOR, JOBURG, WNKFLD, and COLEGE and will send launch progress and receive status reports. The above-named stations will be electronically isolated by the communications computers and will be unable to receive teletype messages unless a mission precedence is assigned to the message. The network isolation grouping will be established by the NASA Communications Division at T-60 minutes at the request of NETCON.

3.2 LAUNCH PHASE

During the launch phase, control of STADAN will be exercised by the T&DS Operations Director in SOCC. The following persons will assist the T&DS Operations Director, H. Hoff/A. Ferris, during this phase:

Ground Operations Manager, G. Harris
Network Controller, E. Quirey
Communications Controller, (Comm. Div.)
Data Systems Scientist, A. Johnson
Tracking and Data-Acquisition Systems Manager, C. Maskaleris
Display Manager, W. Healy

Additional personnel for SOCC support will be appointed as required by the T&DS Operations Director and as dictated by project requirements.

The launch phase will start at T-60 minutes and will continue until terminated by the T&DS Operations Director. The Network Controller will notify the stations at the end of the launch phase.

During this phase, all information pertaining to the launch will be relayed, as required, by the personnel assigned as phone talkers and communicators.

- JOBURG will send the spacecraft time correlated against the station time to SOCC by SCAMA telephone and this information will be relayed to the Project Manager at PMR and to NTCC

- WNKFLD will telephone its signal acquisition and spin rate information to NETCON for relay to the Project Manager at PMR and to NTCC

- GILMOR acquisition and data-handling information will be relayed to the Project Manager

3.3 POSTLAUNCH PHASE

When notified by SOCC, STADAN will enter the postlaunch phase. During this phase, SOCC personnel will have the following responsibilities.

3.3.1 NETWORK OPERATIONS BRANCH

- Ensure that sufficient STADAN tracking data are obtained for the computation of the spacecraft and Agena vehicle orbits.

- Schedule GILMOR and ROSMAN antenna operations and transmissions (ROSMAN will be scheduled in accordance with established priorities and with project requirements received from NTCC; GILMOR will be used exclusively for Nimbus and is not included in the priority system).

- Send the data-acquisition schedule for GILMOR and ROSMAN to NTCC.

- NTCC will confirm the actual schedule requirements to NETCON within 24 hours after receipt of predictions.

- Give the Ground Operations Manager and NTCC information on GILMOR and ROSMAN outages which affect the Nimbus program. This information will consist of a teletype copy of the station message stating which piece of equipment is out, what remedial action is being taken, estimated time of outage, and the station's ability to partially or fully support the passes scheduled during the outage time. The Ground Operations Manager will inform the Nimbus Operations Manager.

- Provide the Ground Operations Manager with STADAN support reports for three consecutive days after launch. The reports will show the STADAN support activities, the number of tracking messages received, and any unusual occurrences. The report will be ready by 0600 local time each day.

- Provide the Ground Operations Manager with daily STADAN support summaries beginning at T+4 days and continuing throughout the active lifetime of the spacecraft. Any unusual occurrences will be reported, as known, during the normal 8:00 to 4:30 working day and the Ground Operations Manager will be notified at home after the normal working day if the occurrence is of a serious nature; the senior Network Controller on duty will decide the relative seriousness of the problem.

- Give the Ground Operations Manager the AGC and antenna x, y plots recordings sent from the DAF stations.

- Provide teletype communications to and from GILMOR for NTCC. NTCC will give all outgoing messages addressed to GILMOR and ROSMAN to NETCON for transmission. Outgoing messages will use the NETCON message format which has no FROM line; the first line in the text references the spacecraft's international designation (example: Reference 1964 10A). NETCON will transmit all outgoing messages in accordance with the originator's assigned precedence. The originator of a teletype message will sign his name at the bottom of the message and will encircle his name. The NTCC Manager or Data Operations Supervisor will sign all messages to indicate that the message is cleared for release.

- Spacecraft data and pass summary reports transmitted by teletype will be received in NTCC during and following GILMOR interrogations.

- Give the Ground Operations Manager a copy of the pass summaries received from ROSMAN and GILMOR.

3.3.2 SPACEFLIGHT BRANCH

During this phase, the Ground Operations Manager will actively work with the project to ensure full support of T&DS as established before launch by the Tracking and Data-Acquisition Systems Manager. In addition, the Ground Operations Manager will:

- Solve any interface problems which might exist between the project and the elements of T&DS.

- Offer his assistance and suggestions to the project in establishing operations procedures.

- Keep the Tracking and Data-Acquisition Systems Manager fully informed of operations and will work through the Tracking and Data-Acquisition Systems Manager when new or changes to existing requirements are originated by the project.

- Submit a morning report to the Assistant Director, T&DS, for the first three days after launch, showing the status of the support given by T&DS. Periodic reports as required will be given to the appropriate NE&O Division personnel and a weekly NE&O Division progress report will be given to the Tracking and Data-Acquisition Systems Manager for inclusion in his report to the Project Manager.

- Keep the Nimbus Operations Manager aware of the status of all T&DS support activities.

3.3.3 PROJECT RESOURCES OFFICE (PRO)

During postlaunch operations the Ground Operations Manager will replace the Tracking and Data-Acquisition Systems Manager and will be responsible for daily operations of the T&DS ground systems in support of Nimbus.

4. DATA SYSTEMS DIVISION

The T&DS Data Systems Division is responsible for determining the Nimbus orbit and computing the tracking and data-acquisition predictions. Specifically, the Data Systems Division will perform the following:

4.1 DATA SYSTEMS DIVISION FUNCTIONS

- Accept, prepare, and analyze tracking observations from the STADAN network and other sources as needed

- Determine spacecraft orbit on the basis of the tracking observations and provide orbital elements

- Provide updated predictions to SOCC for teletype to ROSMAN and GILMOR until the orbit is determined, with a copy to NTCC

- Compute equator crossings and STADAN interferometer station alerts

- Compute topocentric prediction tapes for ROSMAN and GILMOR

- Provide orbit, solar, and station acquisition predictions as follows:

  Spacecraft location vs. time
  Solar illumination of the subsatellite point
  Range, azimuth, and elevation for acquisition stations
  Sun incident angle with respect to the orbital plane
  Satellite day and satellite night

- Compute the Nimbus APT Daily and Weekly Alert and Ephemeris Prediction messages

- Provide the orbital elements for the CDC 924 gridding computers

- Evaluate Agena 136.65-Mc beacon data and study Thor-Agena separation

A chronology of Data Systems Division responsibilities and activities follows:

4.2 PRELAUNCH OPERATIONS

Schedule for Prelaunch Phase Preparations

Time before Launch Date in Days	Event	Responsibility of
30	Conference is held with Network Engineering and Operations Division concerning tracking network and tracking facility requirements.	Data Systems Scientist
30	Orbital elements are determined from which are obtained the initial conditions for nominal orbit computations.	Data Systems Scientist
30	Advanced Orbital Programming Branch, Operational Computing Branch, and Theory and Analysis Office are requested to make personnel assignments for the launch and early orbit determination period.	Data Systems Scientist
30	Tentative operations plan for the launch and early orbit determination period is completed.	Data Systems Scientist
30	Prepare World Map and Satellite Acquisition Data (WMSAD) for nominal orbit, including x-y coordinates for acquisition intervals.	Data Systems Scientist
30	Prepare WMSAD for no-second-burn orbit	Data Systems Scientist
20	Orbital elements and equator crossings for nominal orbit to SAO	Data Systems Scientist

Time before Launch Date in Days	Event	Responsibility of
14	Computation and transmission of the APT daily messages begins on a daily basis.	Data Systems Scientist, Minitrack Section
14	Computation and preparation of the APT weekly messages and WMSAD predicts begins on a weekly basis.	Data Systems Scientist, Computer Services Section
10	Nominal world map and station predictions for the orbit are sent to the NTCC and Network Operations Branch, Network Engineering and Operations Division, with the predictions being transmitted to the stations.	Data Systems Scientist, Orbit Determination Section, Network Operations Branch, Minitrack Section, Computer Services Section
7	Personnel assignments for launch and early orbit determination period are made.	Advanced Orbital Prog. Br., Operational Computing Br., Theory and Analysis Office
7	Schedule of early STADAN interferometer, radar, and optical tracking data acquisition is prepared.	Minitrack Section
7	Predictions are computed for variations from nominal injection conditions.	Data Systems Scientist, Operational Computing Branch

Time before Launch Date in Days	Event	Responsibility of
7	Tracking network and tracking facility arrangements are verified with Network Engineering and Operations Division.	Data Systems Scientist
7	Request is made of Network Operations Branch for emergency availability of diesel power for the computer during the launch and early orbit determination period.	Operational Computing Branch
3	Statement of computer program requirements for the launch and early orbit determination period is sent to the Operational Computing Branch.	Data Systems Scientist
3	Names of Data Systems Division personnel required to be present during the launch and early orbit determination period are sent to the Network Operations Branch.	Data Systems Scientist
2	Readiness of required programs is confirmed.	Advanced Orbital Prog. Br., Orbit Determination Section
1	Briefing of personnel involved in the launch and early orbit determination period is conducted.	Data Systems Scientist
1	Operational Computing Branch confirms availability of computers for orbit determination.	Operational Computing Branch

4.3 ORBIT DETERMINATION

It is planned to launch Nimbus A to the southwest from PMR. Nominal values for the principal elements of the orbit are as follows:

Period	- 103 minutes
Perigee	- 568 statute miles (915 kilometers)
Apogee	- 572 statute miles (920 kilometers)
Inclination	- 81 degrees retrograde

The world map with the nominal Nimbus A subpoint track overlay is given in Figure IV-6. Equator crossings referenced to launch time are listed in Table VI-2. To use the overlay, place the ascending node at the longitude as given in Table VI-2 for the desired orbit.

The optimum launch time (Table IV-3 and Figure IV-7) occurs when the angle between the orbit plane and the earth-sun line (sun incidence line) is zero. The launch window is defined by limits of sun incidence angle of ±8° (approximately ±34 minutes).

It is planned that Agena B second-burn shutdown or injection will take place about 54.9 minutes after launching and that the spacecraft will be separated from the Agena about 56.8 minutes after liftoff. It is anticipated that sufficient tracking data will be available to make possible the determination of a preliminary orbit for Nimbus A within about ten hours after launching.

4.3.1 DATA SYSTEMS DIVISION MANAGEMENT PLAN

A. G. Johnson of the Theory and Analysis Office has the responsibility to coordinate the orbit determination plan. Responsibility for the Nimbus A orbit determination rests with R. G. Chaplick of the Theory and Analysis Office. A. Johnson will have the division operational responsibility during the period of launch and early determination of the orbit of Nimbus A. A. Johnson will prepare such reports and documents as may be necessary, including the postflight analysis.

T. P. Gorman, Head of the Advanced Orbital Programming Branch, is responsible for such programming support as may be needed because of special project demands. He will also arrange for representation from the programming staff during the orbit determination period for the purpose of providing, in an emergency, detailed information concerning every capability of the entire orbit determination program library, as well as guidance in the use of such programs.

Figure IV-6, Subsatellite Track, follows Appendix C

Table IV-2

Equator Crossings for Nimbus A

Time after Liftoff	Orbit	Longitude	Height (km)
$01^h\ 01^m\ 22^s$	1	38.78°E	916.2
$02^h\ 44^m\ 47^s$	2	12.92°E	916.3
$04^h\ 28^m\ 13^s$	3	12.93°W	916.3
$06^h\ 11^m\ 38^s$	4	38.78°W	916.3
$07^h\ 55^m\ 03^s$	5	64.64°W	916.3
$09^h\ 39^m\ 28^s$	6	90.49°W	916.3
$11^h\ 22^m\ 54^s$	7	116.35°W	916.3
$13^h\ 05^m\ 19^s$	8	142.21°W	916.3
$14^h\ 49^m\ 44^s$	9	168.06°W	916.3
$16^h\ 32^m\ 09^s$	10	166.07°E	916.3
$18^h\ 16^m\ 35^s$	11	140.22°E	916.3
$19^h\ 59^m\ 00^s$	12	114.36°E	916.3
$21^h\ 42^m\ 25^s$	13	88.50°E	916.4
$23^h\ 25^m\ 51^s$	14	62.65°E	916.4
$25^h\ 09^m\ 16^s$	15	36.79°E	916.4
$26^h\ 52^m\ 41^s$	16	10.94°E	916.4
$28^h\ 36^m\ 06^s$	17	14.91°W	916.4
$30^h\ 19^m\ 32^s$	18	40.77°W	916.4
$32^h\ 02^m\ 57^s$	19	66.67°W	916.4

Table IV-2 (continued)

Equator Crossings for Nimbus A

Time after Liftoff	Orbit	Longitude	Height (km)
$33^h\ 46^m\ 22^s$	20	92.48°W	916.4
$35^h\ 29^m\ 47^s$	21	118.33°W	916.4
$37^h\ 13^m\ 13^s$	22	144.19°W	916.4
$38^h\ 56^m\ 36^s$	23	170.05°W	916.4
$40^h\ 40^m\ 03^s$	24	164.09°E	916.5
$42^h\ 23^m\ 28^s$	25	138.23°E	916.5
$44^h\ 06^m\ 54^s$	26	112.38°E	916.5
$45^h\ 50^m\ 19^s$	27	86.52°E	916.5
$47^h\ 33^m\ 44^s$	28	60.66°E	916.5
$49^h\ 17^m\ 09^s$	29	34.81°E	916.5
$51^h\ 00^m\ 35^s$	30	8.95°E	916.5

B. Richardson, Head of the Orbit Determination Section, Operational Computing Branch, is responsible for the preparation and prompt machine computation of world maps and station predictions, and for any special computations that may be required. He will be responsible for the availability and proper running of the various programs used for orbit determination and predictions, and will arrange for suitable representation from his section during the launch and orbit determination period.

J. Kohout, Head of the Minitrack Section, Operational Computing Branch, will receive the nominal station predictions prior to launch and is responsible for appropriate processing and transmittal of this data to tracking stations. He will also be responsible for the preparation of a schedule of estimated early tracking data acquisitions for use during

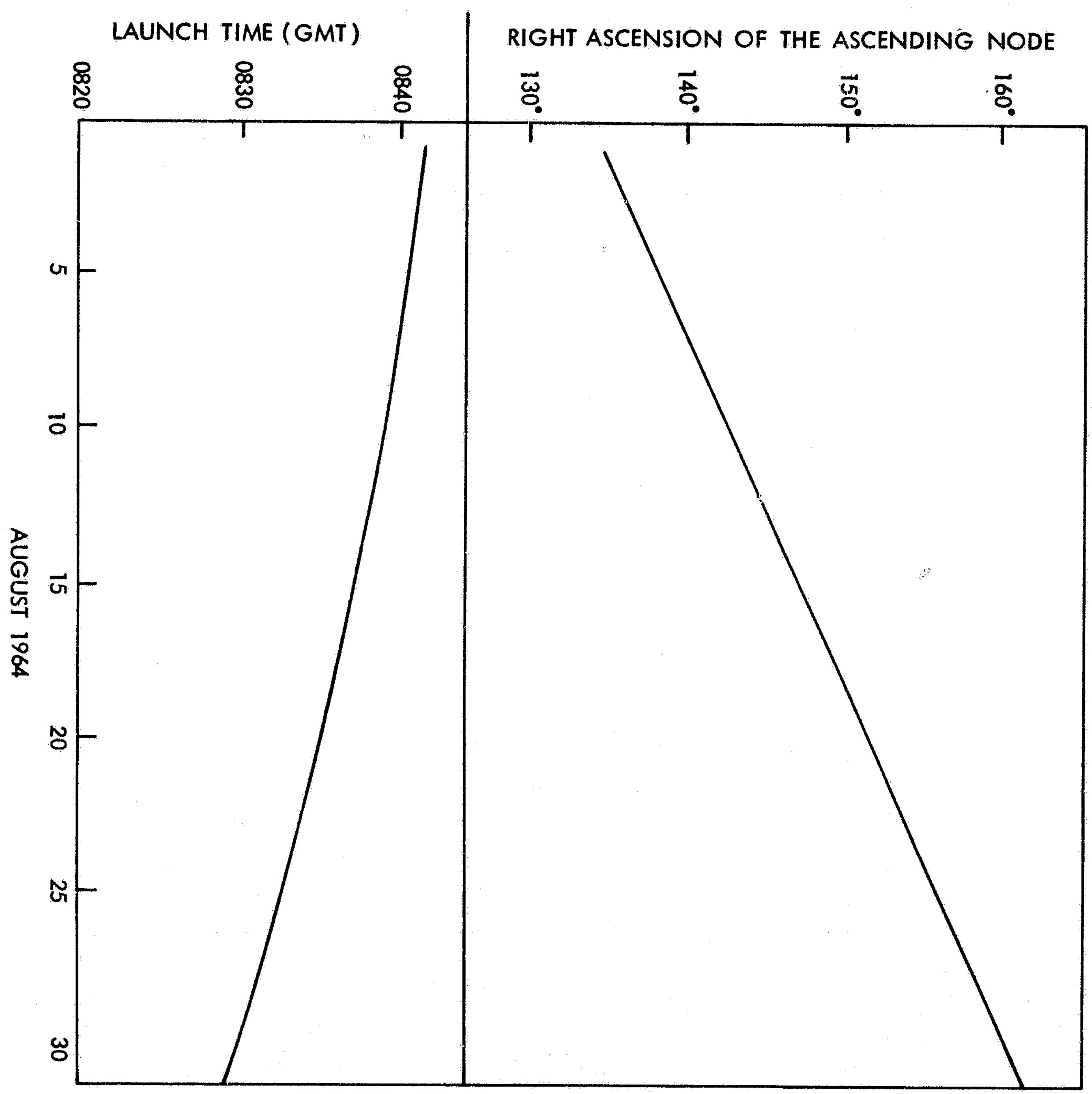


Figure IV-7 – Optimum Launch Times

Table IV-3

Launch Times for the Month of August

Sun Incidence Angle = 0.000°			
Launch Time (GMT)			Right Ascension of the Ascending Node
Day	Hour	Minute	
1	8	41.51	134.5°
2	8	41.26	135.4°
3	8	41.00	136.4°
4	8	40.73	137.3°
5	8	40.44	138.2°
6	8	40.14	139.1°
7	8	39.83	140.0°
8	8	39.51	140.9°
9	8	39.17	141.8°
10	8	38.83	142.7°
11	8	38.47	143.6°
12	8	38.10	144.5°
13	8	37.72	145.4°
14	8	37.33	146.3°
15	8	36.93	147.2°
16	8	36.51	148.1°
17	8	36.09	148.9°
18	8	35.66	149.8°
19	8	35.21	150.7°
20	8	34.76	151.6°
21	8	34.30	152.4°
22	8	33.82	153.3°
23	8	33.34	154.2°
24	8	32.85	155.0°
25	8	32.36	155.9°
26	8	31.85	156.7°
27	8	31.34	157.6°
28	8	30.82	158.5°
29	8	30.29	159.3°
30	8	29.75	160.2°
31	8	29.21	161.0°

the launch and orbit determination period. He will arrange for suitable representation from his section during the launch and orbit determination period, and will be responsible for receipt and processing of tracking data for input to the IBM 7094 General Orbit Determination System and for the transmission of predictions to the STADAN stations as needed.

C. Mentges, Head of the Computer Services Section, Operational Computing Branch, will be responsible for arranging for the presence of the computer operating personnel and for the use of the necessary computing facilities.

4.3.2 ORBIT DETERMINATION PLAN

Data obtained from the guidance system, tracking data recorded during powered flight, and estimates of injection orbital elements will be transmitted to GSFC.

Table IV-4 gives a schedule of the times at which STADAN interferometer stations will have axes crossings during the first seven orbits. Under normal conditions data will start arriving on the teletypes in Room 135 of Building 3 about 30 minutes after recording has started. Table IV-5 gives a list of the times at which it is expected that data will be taken by additional tracking facilities. The Minitrack Section will be responsible for using the CDC-160A and peripheral equipment to process these data and for furnishing indications of the quality of the data. Data on punched cards (Figures IV-8, IV-9, IV-10 and Tables IV-6, IV-7, IV-8) together with indications of their potential usefulness, will be hand carried to the Theory and Analysis Office representative. The representative of the Orbit Determination Section will be responsible for processing the STADAN interferometer data in the General Orbit Determination Input Program and for preparing the data tape for use in the General Orbit Determination Programs.

The Data Systems Scientist and the Theory and Analysis Office representative will be responsible for conducting the orbit determination including the differential correction, i.e., for the selection, evaluation, and interpretation of the data; the selection of the orbit theory and the differential correction theory; the analysis and interpretation of the results; the use of the results for predictions; the releasing of the results for other operational and public information purposes; and the decision as to when the early orbit determination phase has been completed.

Table IV-4

Interferometer Tracking Data Schedule for Nimbus A

Time after Liftoff		Station	Zenith Angle	Range (km)	Recording Rate
01^h	15^m	WNK	E 74°	2188	60 lpm for 1/2 min.
01^h	33^m	COL	E 48°	1286	30 lpm for 1 min.
02^h	36^m	JOB	W 49°	1310	30 lpm for 3 min.
02^h	59^m	WNK	W 08°	931	60 lpm for 1/2 min.
03^h	17^m	COL	W 25°	1014	60 lpm for 1/2 min.
05^h	28^m	OOM	E 50°	1342	30 lpm for 1 min.
06^h	25^m	NEW	E 02°	928	60 lpm for 1/2 min.
07^h	11^m	OOM	W 68°	1893	30 lpm for 1 min.
07^h	45^m	SNT	E 63°	1689	60 lpm for 1/2 min.
07^h	54^m	QUI	E 68°	1904	30 lpm for 2 min.
08^h	02^m	FTM	E 57°	1484	60 lpm for 1/2 min.
08^h	06^m	BPO	E 15°	960	60 lpm for 1/2 min.
08^h	08^m	GFO	E 66°	1831	60 lpm for 1/2 min.
09^h	28^m	SNT	W 57°	1502	60 lpm for 1/2 min.
09^h	37^m	QUI	W 63°	1685	60 lpm for 1/2 min.
09^h	51^m	GFO	W 34°	1086	60 lpm for 1/2 min.
11^h	31^m	MOJ	W 45°	1244	60 lpm for 1/2 min.
11^h	40^m	COL	E 23°	991	60 lpm for 1/2 min.
13^h	23^m	COL	W 49°	1308	60 lpm for 1/2 min.

Table IV-5

Additional Tracking Data Schedule for the Satellite Nimbus A

Time after Liftoff	Station	Reference Elevation
$0^h\ 55^m$ to $1^h\ 02^m$	PRETOA	19°
$1^h\ 41^m$ to $1^h\ 42^m$	1MAUIO	7°
$1^h\ 41^m$ to $1^h\ 56^m$	1HWPMR	50°
$2^h\ 31^m$ to $2^h\ 45^m$	PRETOA	37°
$3^h\ 23^m$ to $3^h\ 25^m$	1MAUIO	6°
$3^h\ 25^m$ to $3^h\ 36^m$	1HWPMR	14°
$5^h\ 05^m$ to $5^h\ 09^m$	1TOKYO	11°
$6^h\ 21^m$ to $6^h\ 32^m$	1MOORE	14°
$6^h\ 21^m$ to $6^h\ 33^m$	1TRDAD	12°
$6^h\ 46^m$ to $6^h\ 52^m$	1TOKYO	50°
$7^h\ 52^m$ to $8^h\ 06^m$	1TRDAD	48°
$8^h\ 01^m$ to $8^h\ 15^m$	1MOORE	80°
$8^h\ 03^m$ to $8^h\ 11^m$	1LARDO	6°
$8^h\ 05^m$	FTSTEW	38°
$8^h\ 05^m$	MISLAK	18°
$8^h\ 30^m$ to $8^h\ 36^m$	1TOKYO	9°
$9^h\ 40^m$ to $9^h\ 55^m$	1LARDO	73°
$9^h\ 44^m$ to $9^h\ 56^m$	1MOORE	11°
$9^h\ 49^m$	ELPHAB	46°

Table IV-5 (Continued)

Additional Tracking Data Schedule for the Satellite Nimbus A

Time after Liftoff	Station	Reference Elevation
$9^h\ 49^m$	FTSTEW	20°
$9^h\ 49^m$	MISLAK	45°
$9^h\ 49^m$	SANDIG	20°
$10^h\ 16^m$ to $10^h\ 19^m$	INATAL	23°
$11^h\ 24^m$ to $11^h\ 35^m$	1LARDO	10°
$11^h\ 59^m$ to $12^h\ 03^m$	1NATAL	14°
$11^h\ 59^m$ to $12^h\ 03^m$	1SHRAZ	27°
$12^h\ 16^m$ to $12^h\ 30^m$	PRETOA	22°

Tracking data will be processed in the input program by the Orbit Determination Section. The differential correction will be initiated by the Theory and Analysis Office representative and Staff. As more tracking data become available, the differential correction will be continued. The Orbit Determination Section will be responsible for transmitting world maps and printed versions of station predictions to the Network Engineering and Operations Division and for furnishing prediction magnetic tapes to the Minitrack Section. The Minitrack Section will be responsible for transmitting the teletype versions of predictions to the Communications Division.

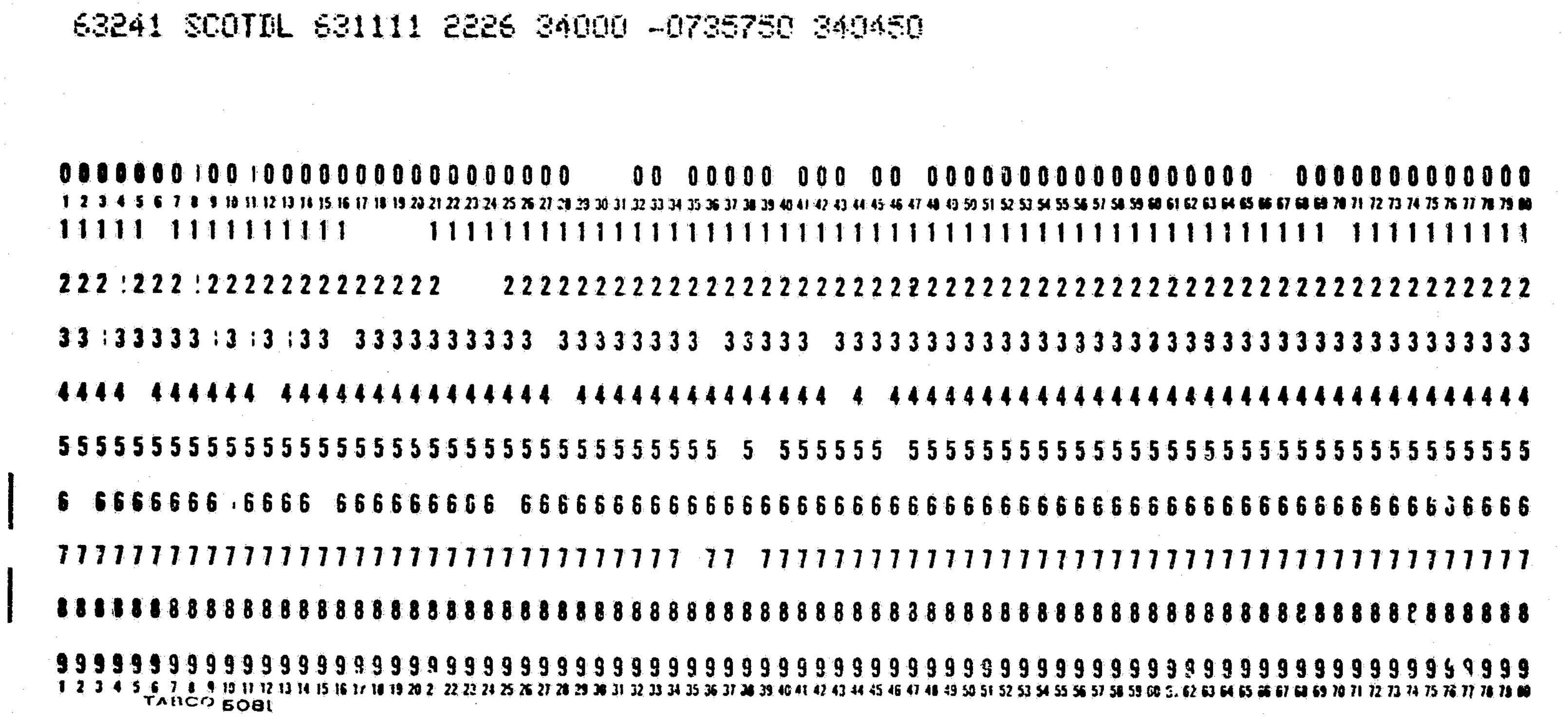


Figure IV-8 – Format of Radar and Space Surveillance Observation Cards

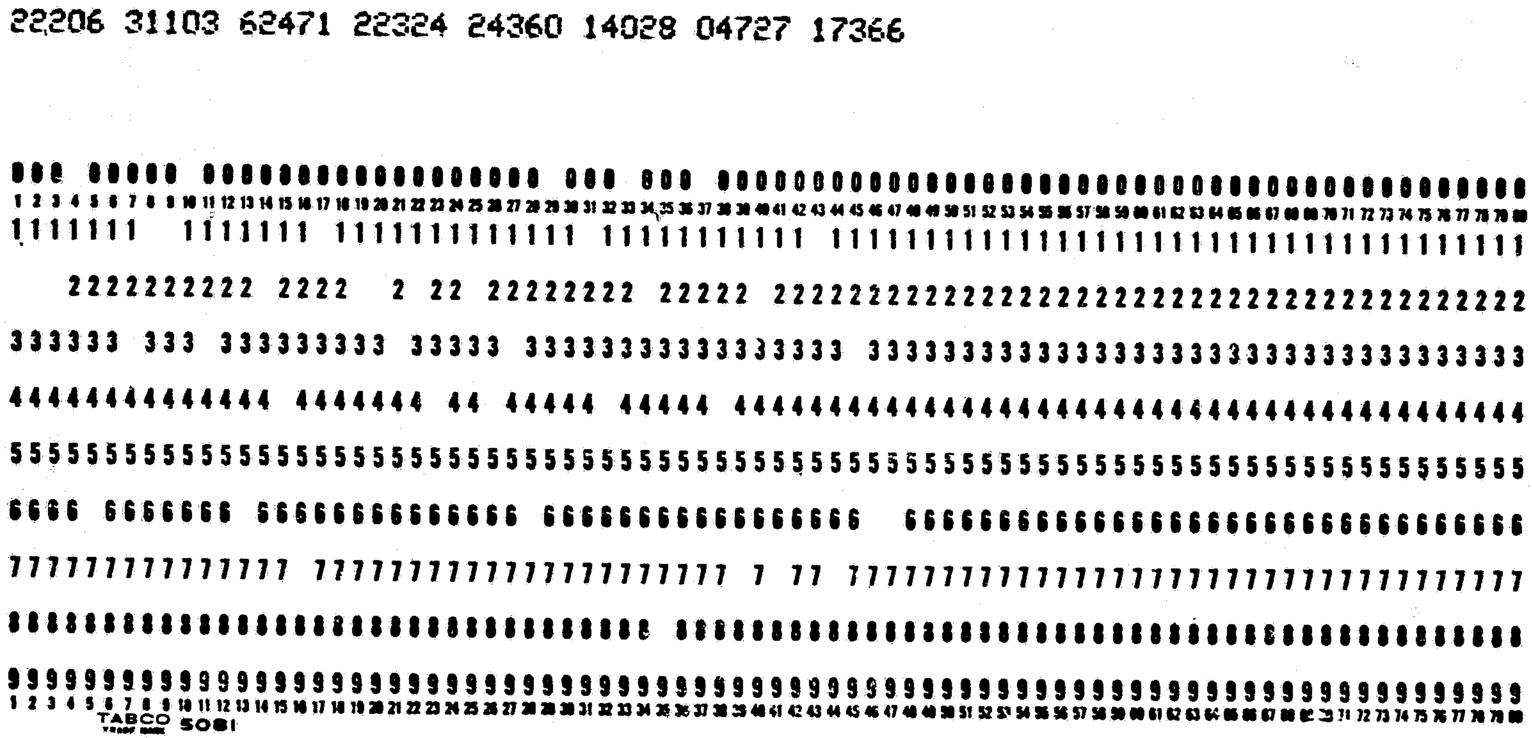


Figure IV-9 – Format of Baker-Nunn Observation Cards

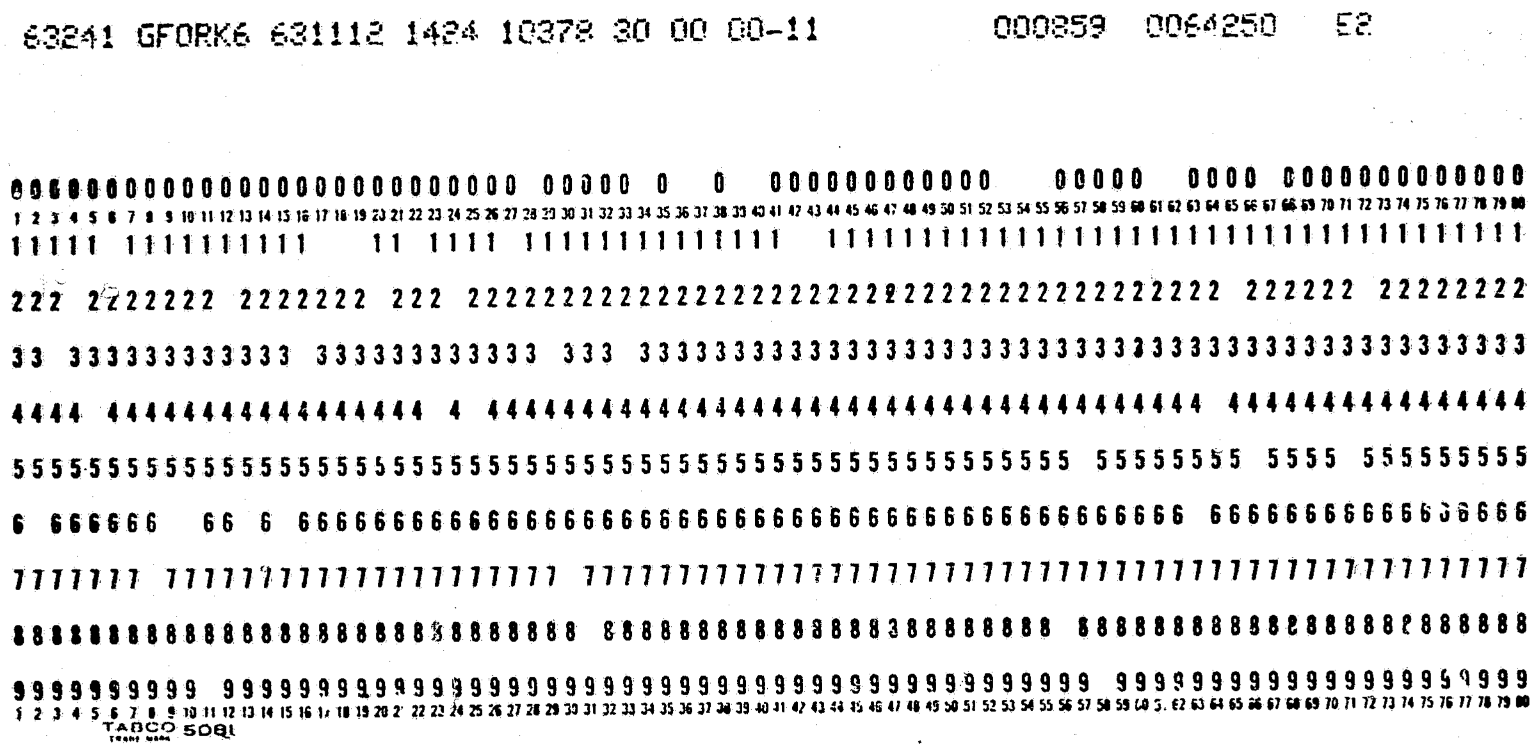


Figure IV-10 – Format of Interferometer Observation Card

Table IV-6

Format of Radar and Space Surveillance Observation Cards

Card Column	Data	Sample
1	Space	
2-6	Satellite Code (I.D. number)	63241
7	Space	
8-13	Station label	SCOTDL
14	Space	
15-16	Year	63
17-18	Month	11
19-20	Day	11
21	Space	
22-23	Hour	22
24-25	Minute	26
26	Space	
27-28	Second	34
29-31	Millisecond	000
32	Space	
33-40	Azimuth in degrees (decimal understood between columns 36 and 37)	-0735750
41-47	Elevation in degrees (decimal understood between columns 43 and 44)	+340450
48-65	Spaces	
66-67	Zeroes	00
68-69	Spaces	
70	One (1)	1

Table IV-7

Format of Baker-Nunn Observation Card

Card Column	Data	Sample
1-3	222	222
4-5	Station number	06
6	Space	
7	Year	3
8-9	Month	11
10-11	Day	03
12	Space	
13-17	Satellite code (5 digits)	62471
18	Space	
19	Irrelevant (1 digit)	2
20-21	Hour	23
22-23	Minute	24
24	Space	
25-26	Second	24
27-29	Millisecond	360
30	Space	
31-32	Right ascension (hours)	14
33-35	Right ascension (minutes with decimal understood between columns 34 and 35)	028
36	Space	
37	Sign (0 for +, 1 for -)	0
38-39	Declination (degrees)	47
40-41	Declination (fraction of degrees)	27
43-47	Checkword (5 digits)	17366

Table IV-8

Format of Interferometer Observation Card

Card Column	Data	Sample
1	Space	
2-6	Satellite Code (I.D. number)	63241
7	Space	
8-13	Station label	GFORKS6
14	Space	
15-16	Year	63
17-18	Month	11
19-20	Day	12
21	Space	
22-23	Hour	14
24-25	Minute	24
26	Space	
27-28	Second	10
29-31	Millisecond	378
32	Space	
33-34	Signal level indicator	30
35-37	Smoothing correction to raw mid-data in phase counts	+00
38-40	Medium ambiguity resolution error in medium phase counts	+00

Table IV-8 (Continued)

Format of Interferometer Observation Card

Card Column	Data	Sample
41-43	Coarse ambiguity resolution error in coarse phase counts	-11
52-58	Direction cosine rate of change per second (decimal understood between columns 53 and 54)	000859
59	Space	
60-67	Direction cosine (decimal understood between columns 61 and 62)	+00064250
68-70	Blank	
71	Antenna indicator (E - equatorial, P - polar)	E
72	2-L East direction cosine 3-M North direction cosine	2

4.4 POSTLAUNCH OPERATIONS

Event	Responsibility of	Sent to
Accept prepare, and analyze tracking from the STADAN network and other sources as needed. (Tables IV-6, IV-7, IV-8, and Figures IV-8, IV-9, and IV-10)	Data Processing Engineer Minitrack Section	Orbit Determination Section
Determine spacecraft orbit on the basis of the tracking observations and provide orbital elements	Data Processing Engineer Orbit Determination Section Minitrack Section	NTCC/NDHS STADAN
Compute equator crossings and STADAN interferometer station alerts	Orbit Determination Section Minitrack Section	STADAN NTCC/NDHS
Compute topocentric prediction tapes for ROSMAN and GILMOR	Orbit Determination Section Minitrack Section	DAF Stations
Provide WMSAD's containing orbit, solar, and station acquisition predictions	Data Processing Engineer Theory and Analysis Office	NTCC/NDHS DAF Stations
Compute Nimbus APT Daily and Weekly Alert and Ephemeris Prediction messages	Data Processing Engineer Theory and Analysis Office Minitrack Section	NTCC/NDHS NWSC for transmission APT Stations

Event	Responsibility of	Sent to
Provide the orbital elements for the CDC 924 gridding computers	Orbit Determination Section Minitrack Section	NTCC/NDHS
Evaluate Agena beacon data and study Thor-Agena separation	Data Processing Engineer Theory and Analysis Office	Nimbus Project Office

PART V

FIELD STATION OPERATION

Field station operations in support of Nimbus include spacecraft tracking by the STADAN stations, command and data-acquisition at the GILMOR DAF and ROSMAN DAF, the NDHS at GILMOR and GSFC, and meteorological team activity at GILMOR.

STADAN is a net of stations, including twelve stations with interferometer tracking capabilities (formerly called Minitrack), and three 85-foot-dish DAF stations. GSFC T&DS is responsible for STADAN operation; Nimbus project controls the NDHS operation; and USWB assigns the meteorological team for evaluation of meteorological data at GILMOR.

1. TRACKING

The tracking of the Nimbus spacecraft and Agena vehicle will be accomplished in two phases: trajectory and transfer orbit, and the final orbit. The trajectory and transfer orbit will be tracked by the range stations at Point Arguello, San Nicolas Island, and Pretoria, South Africa, using C-band radars. Hawaii and Pretoria will radar track the Agena vehicle after spacecraft separation until the depletion of the Agena C-band beacon batteries.

The orbital tracking phase will be the responsibility of the STADAN stations equipped with interferometer tracking capabilities. For the first week after launch, the Smithsonian Astrophysical Observatory (SAO) Baker-Nunn network and the North American Air Defense Command (NORAD) Space Detection and Tracking System will be requested to provide additional tracking support.

1.1 RANGE TRACKING

The PMR C-band radar tracking stations at Point Arguello and San Nicolas Island will track the vehicle from liftoff through Agena first burn. Real-time radar data at a rate of one sample every six seconds will be sent from the PMR radars to GSFC. PMR will also use the radar data for computing look angles for the AMR Pretoria C-band radar.

Second Agena-burn and spacecraft separation occur in the area over the Malagasy Republic and will be tracked by the AMR Pretoria radar. Real-time radar tracking data of one sample every six seconds will be sent to GSFC for the computation of orbital injection parameters while being sent to AMR for orbital computations.

1.2 STADAN

The following STADAN stations are equipped with interferometer tracking and will track according to the established tracking priorities during the lifetime of the 136.5-Mc spacecraft beacon and the 136.65-Mc Agena vehicle beacon (3 to 5 days).

Station Location	Station Code	Teletype Code
Blossom Point, Md.	BPOINT	GBPT
College, Alaska	COLEGE	GCOL
East Grand Forks, Minn.	GFORKS	GRKS
Fort Myers, Fla.	FTMYRS	GYRS
Goldstone, Calif.	MOJAVE	JAVE
Johannesburg, South Africa	JOBURG	GBUR
Lima, Peru	LIMAPU	GAPU
Quito, Ecuador	QUITOE	GQUI
Santiago, Chile	SNTAGO	GAGO
St. Johns, Newfoundland	NEWFLD	GFLD
Winkfield, England	WNKFLD	LWNK
Woomera, Australia	OOMERA	AOOM

Tracking data are to be taken according to the established standard tracking procedures for near-earth spacecraft and sent to the GSFC Computing Center (GPUT) for processing, reduction, and orbital computation.

1.3 SMITHSONIAN ASTROPHYSICAL OBSERVATORY (SAO)

The SAO Baker-Nunn optical stations are requested to track both the Nimbus spacecraft and the Agena vehicle for the first week after launch and to transmit the field reduced observations to the GSFC Computing Center (GPUT). The orbital elements and equator crossings for the nominal orbit will be sent to SAO at T-20 days to allow time for SAO to get nominal predictions to the field stations. The calculated optical brightness of the spacecraft in a 917-km circular orbit will rarely be brighter than magnitude 7, while the vehicle is expected to be magnitude +4 to +6.

1.4 NORTH AMERICAN AIR DEFENSE COMMAND (NORAD)

The NORAD Space Detection and Tracking system of stations is requested to track the Nimbus spacecraft and launch vehicle and to send the observations to GSFC for orbital computations. Of particular interest will be the time and distance separation of the spacecraft from the launch vehicle.

2. DATA ACQUISITION

The STADAN facilities responsible for executing Nimbus commands and acquiring Nimbus spacecraft and meteorological data are the DAF stations at Gilmore Creek, Alaska (GILMOR) and Rosman, N. C. (ROSMAN). Figure V-1 shows station acquisition for the first 14 orbits. Figure V-2 is a map of the Gilmore Creek area, showing the GILMOR location. Figure V-3 is a block diagram of the DAF-GSFC data communications loop. Operation of these facilities is a responsibility of the GSFC T&DS NE&O Division. Operations will be accomplished under the operational procedures in existence for the STADAN network.

Commands will be generated by the Nimbus Data-Handling System (NDHS) command subsystem and will amplitude modulate the nominal 120-Mc carrier of the command transmitters. Since communication between the command generator at GSFC and the command transmitter at ROSMAN may fail, an emergency tone command generator has been provided at the ROSMAN DAF.

All tracking data acquisition exercises will be scheduled by the GSFC T&DS Network Controller. Additional coverage during the first orbit to determine spacecraft clock time and spin-rate monitoring will be provided by STADAN facilities at Johannesburg, South Africa (JOBURG), and Winkfield, England (WNKFLD).

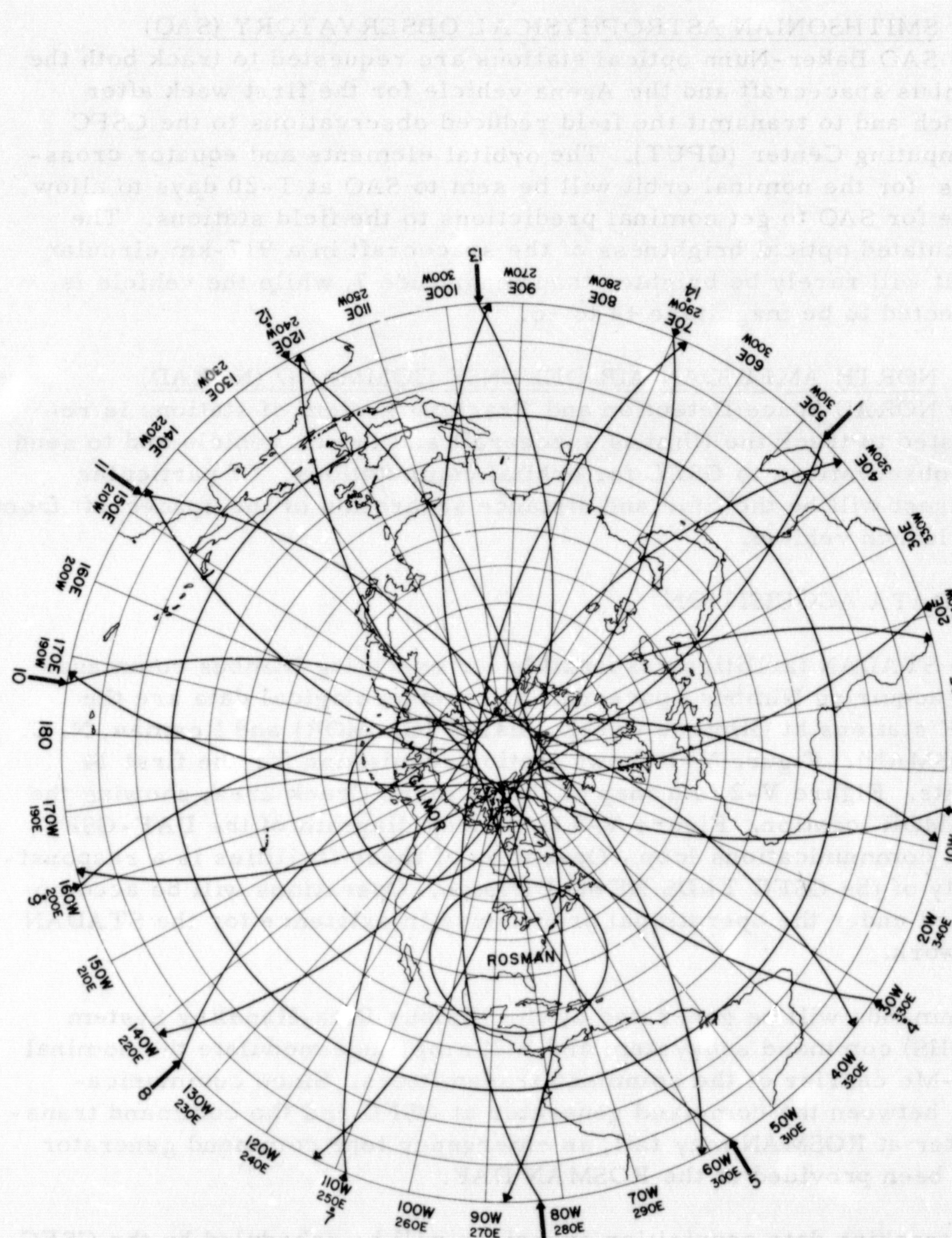


Figure V-1 – Subsatellite Track for First 14 Orbits, Showing 10° Elevation Circles at GILMOR and ROSMAN

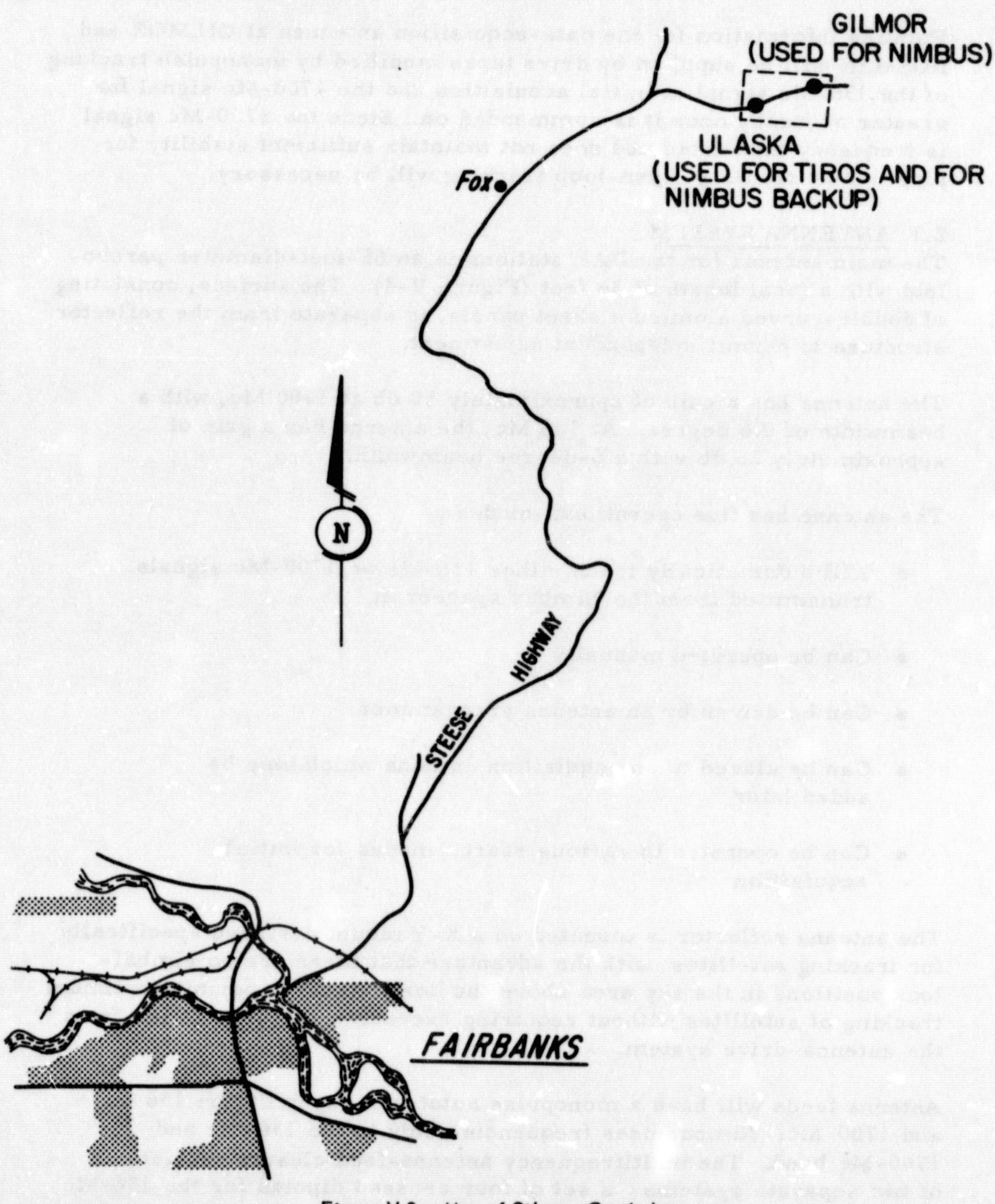


Figure V-2 – Map of Gilmore Creek Area

Pointing information for the data-acquisition antennas at GILMOR and ROSMAN will be supplied by drive tapes modified by monopulse tracking of the 136-Mc signal at initial acquisition and the 1700-Mc signal for greater accuracy once it is commanded on. Since the 1700-Mc signal is frequency-modulated and does not maintain sufficient stability for closed-loop tracking, open-loop tracking will be necessary.

2.1 ANTENNA SYSTEM

The main antenna for the DAF stations is an 85-foot-diameter paraboloid with a focal length of 36 feet (Figure V-4). The surface, consisting of double-curved aluminum sheet panels, is separate from the reflector structure to permit independent adjustment.

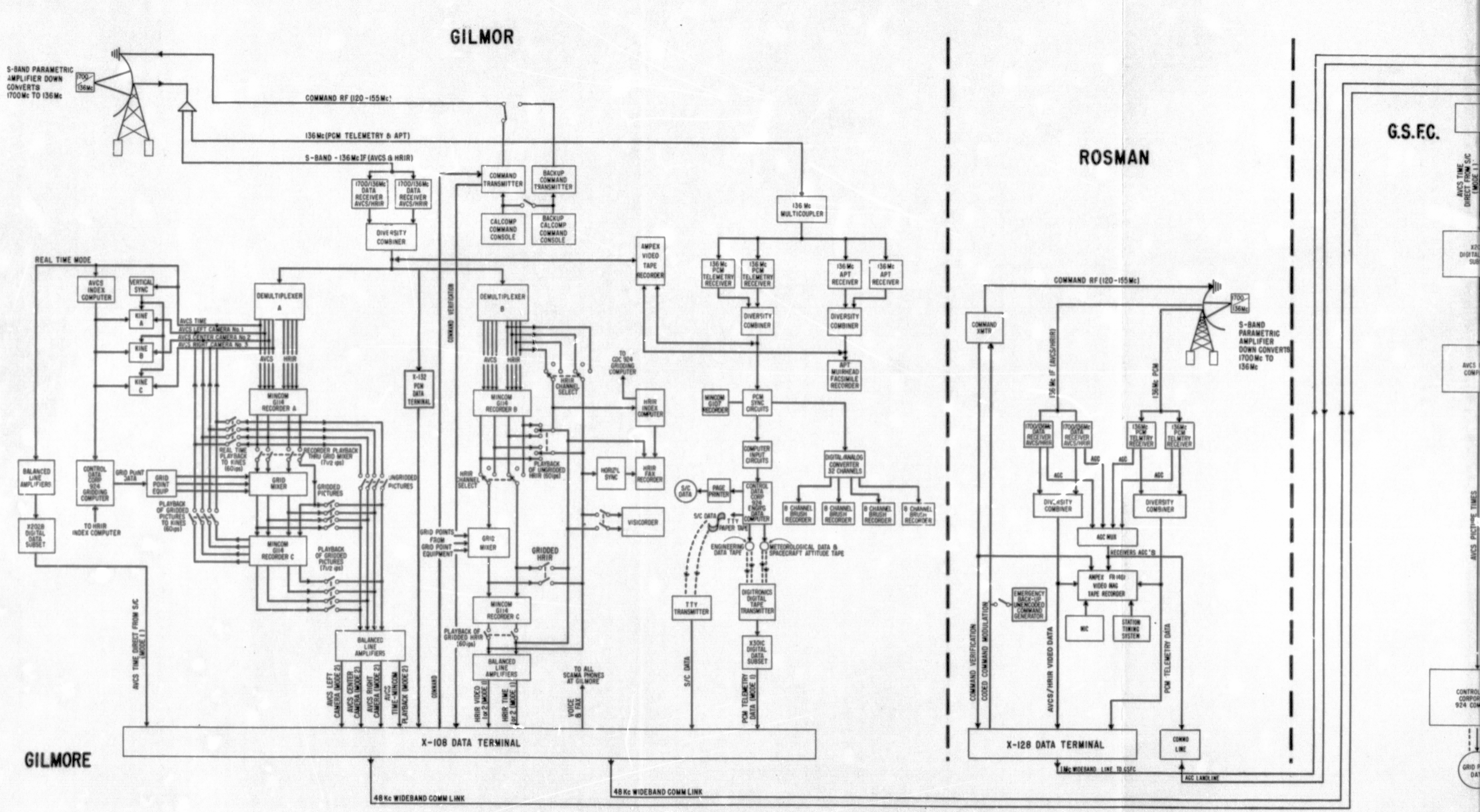
The antenna has a gain of approximately 50 db at 1700 Mc, with a beamwidth of 0.6 degree. At 136 Mc, the antenna has a gain of approximately 26 db with a 6-degree beamwidth.

The antenna has five operational modes:

- Will automatically track either 136-Mc or 1700-Mc signals transmitted from the Nimbus spacecraft
- Can be operated manually
- Can be driven by an antenna programmer
- Can be slaved to an acquisition antenna which may be added later
- Can be operated in various search modes for initial acquisition

The antenna reflector is mounted on a X-Y mount designed specifically for tracking satellites, with the advantage that there are no gimbal-lock positions in the sky area above the horizon. This permits optimum tracking of satellites without requiring excessive shaft velocities from the antenna-drive system.

Antenna feeds will have a monopulse autotrack capability on 136 Mc and 1700 Mc. Nimbus uses frequencies only in the 136-Mc and 1700-Mc band. The multifrequency antenna-feed cluster consists of two separate systems: a set of four crossed dipoles for the 136-Mc to 137-Mc band, and a set of four crossed dipoles for the 1700-Mc band.



GILMOR
ROSMAN
G.S.F.C.
GILMORE
S-BAND PARAMETRIC AMPLIFIER DOWN CONVERTS 1700Mc TO 136Mc
COMMAND RF (120-155Mc)
136Mc (PCM TELEMETRY & APT)
S-BAND - 136Mc IF (AVCS & HRIR)
COMMAND TRANSMITTER
BACKUP COMMAND TRANSMITTER
CALCOMP COMMAND CONSOLE
BACKUP CALCOMP COMMAND CONSOLE
1700/136Mc DATA RECEIVER AVCS/HRIR
DIVERSITY COMBINER
136 Mc MULTICOUPLER
AMPEX VIDEO TAPE RECORDER
136Mc PCM TELEMETRY RECEIVER
136Mc APT RECEIVER
APT MUIRHEAD FACSIMILE RECORDER
REAL TIME MODE
AVCS INDEX COMPUTER
VERTICAL SYNC
KINE A
KINE B
KINE C
DEMULTIPLEXER A
DEMULTIPLEXER B
AVCS TIME
AVCS LEFT CAMERA No. 1
AVCS CENTER CAMERA No. 2
AVCS RIGHT CAMERA No. 3
AVCS
HRIR
MINCOM G114 RECORDER A
MINCOM G114 RECORDER B
MINCOM G114 RECORDER C
X-132 PCM DATA TERMINAL
COMMAND VERIFICATION
HRIR CHANNEL SELECT
TO CDC 924 GRIDDING COMPUTER
HRIR INDEX COMPUTER
MINCOM G107 RECORDER
PCM SYNC CIRCUITS
COMPUTER INPUT CIRCUITS
DIGITAL/ANALOG CONVERTER 32 CHANNELS
8 CHANNEL BRUSH RECORDER
REAL TIME PLAYBACK TO KINES (60cps)
RECORDER PLAYBACK THRU GRID MIXER (7 1/2 cps)
PLAYBACK OF UNGRIDDED HRIR (60 cps)
HORIZ'L SYNC
HRIR FAX RECORDER
BALANCED LINE AMPLIFIERS
CONTROL DATA CORP 924 GRIDDING COMPUTER
GRID POINT DATA
GRID POINT EQUIP
GRID MIXER
GRIDDED PICTURES
UNGRIDDED PICTURES
S/C DATA
PAGE PRINTER
CONTROL DATA CORP 924 COMPUTER
TO HRIR INDEX COMPUTER
X202B DIGITAL DATA SUBSET
PLAYBACK OF GRIDDED PICTURES TO KINES (60cps)
PLAYBACK OF GRIDDED PICTURES (7 1/2 cps)
GRID POINTS FROM GRID POINT EQUIPMENT
GRIDDED HRIR
VISICORDER
TTY PAPER TAPE
ENGINEERING DATA TAPE
METEOROLOGICAL DATA & SPACECRAFT ATTITUDE TAPE
TTY TRANSMITTER
DIGITRONICS DIGITAL TAPE TRANSMITTER
X301C DIGITAL DATA SUBSET
PLAYBACK OF GRIDDED HRIR (60cps)
TO ALL SCAMA PHONES AT GILMORE
AVCS TIME DIRECT FROM S/C (MODE 1)
AVCS LEFT CAMERA (MODE 2)
AVCS CENTER CAMERA (MODE 2)
AVCS RIGHT CAMERA (MODE 2)
AVCS TIME-MINCOM PLAYBACK (MODE 2)
COMMAND
HRIR VIDEO (1 or 2 (MODE 1))
HRIR TIME (1 or 2 (MODE 1))
VOICE & FAX
S/C DATA
PCM TELEMETRY DATA (MODE 1)
X-108 DATA TERMINAL
48Kc WIDEBAND COMM LINK
COMMAND XMTR
136Mc IF (AVCS/HRIR)
136Mc PCM
AGC
AGC MUX
RECEIVERS AGC'S
AMPEX FR 1400 VIDEO MAG TAPE RECORDER
EMERGENCY BACK-UP UNENCODED COMMAND GENERATOR
MIC
STATION TIMING SYSTEM
COMMAND VERIFICATION
CODED COMMAND MODULATION
AVCS/HRIR VIDEO DATA
PCM TELEMETRY DATA
X-128 DATA TERMINAL
COMMO LINE
1Mc WIDEBAND LINE TO GSFC
AGC LANDLINE
AVCS TIME DIRECT FROM S/C (MODE 1)
AVCS PICTURE TIMES
GRID POINT DATA

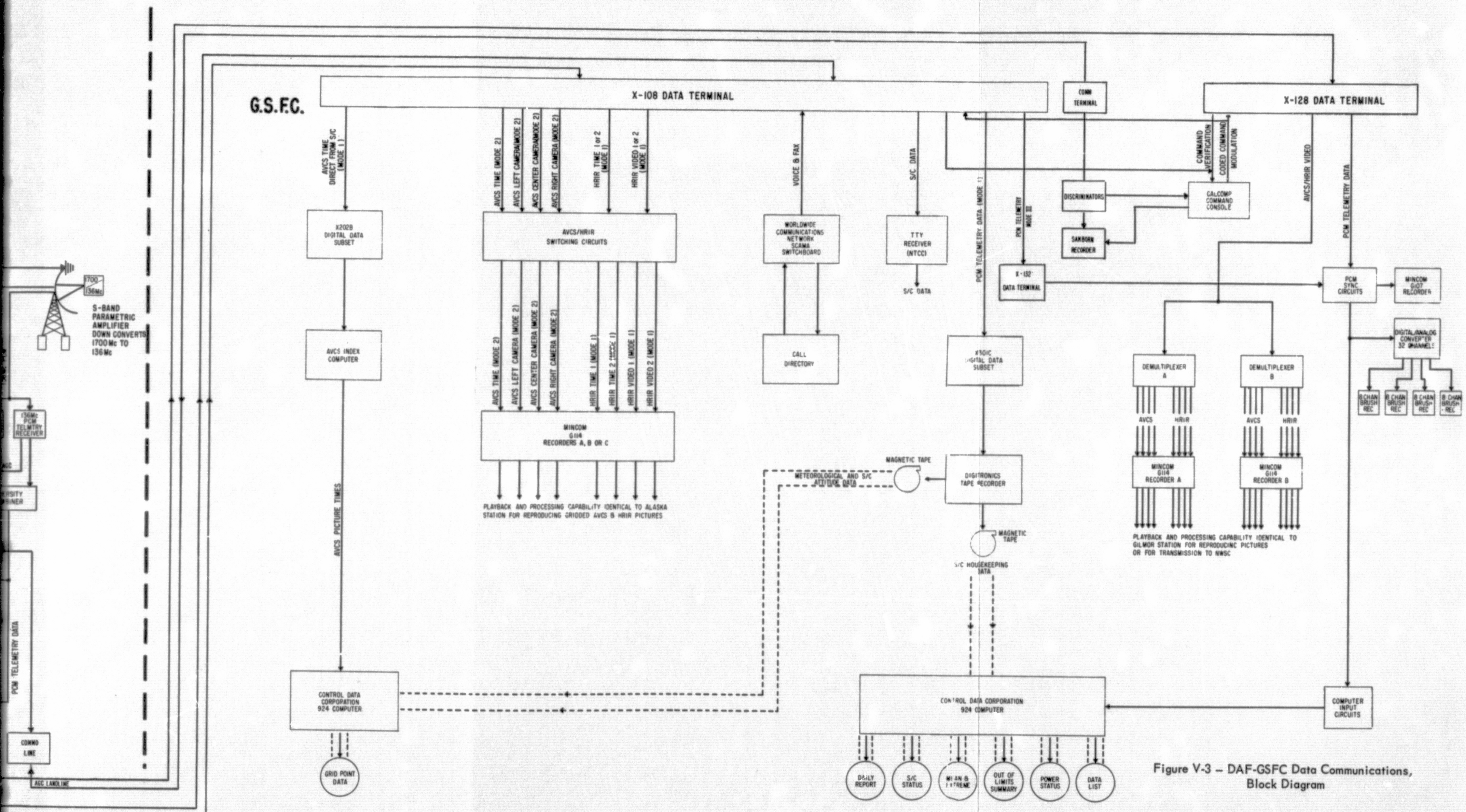


Figure V-3 – DAF-GSFC Data Communications, Block Diagram

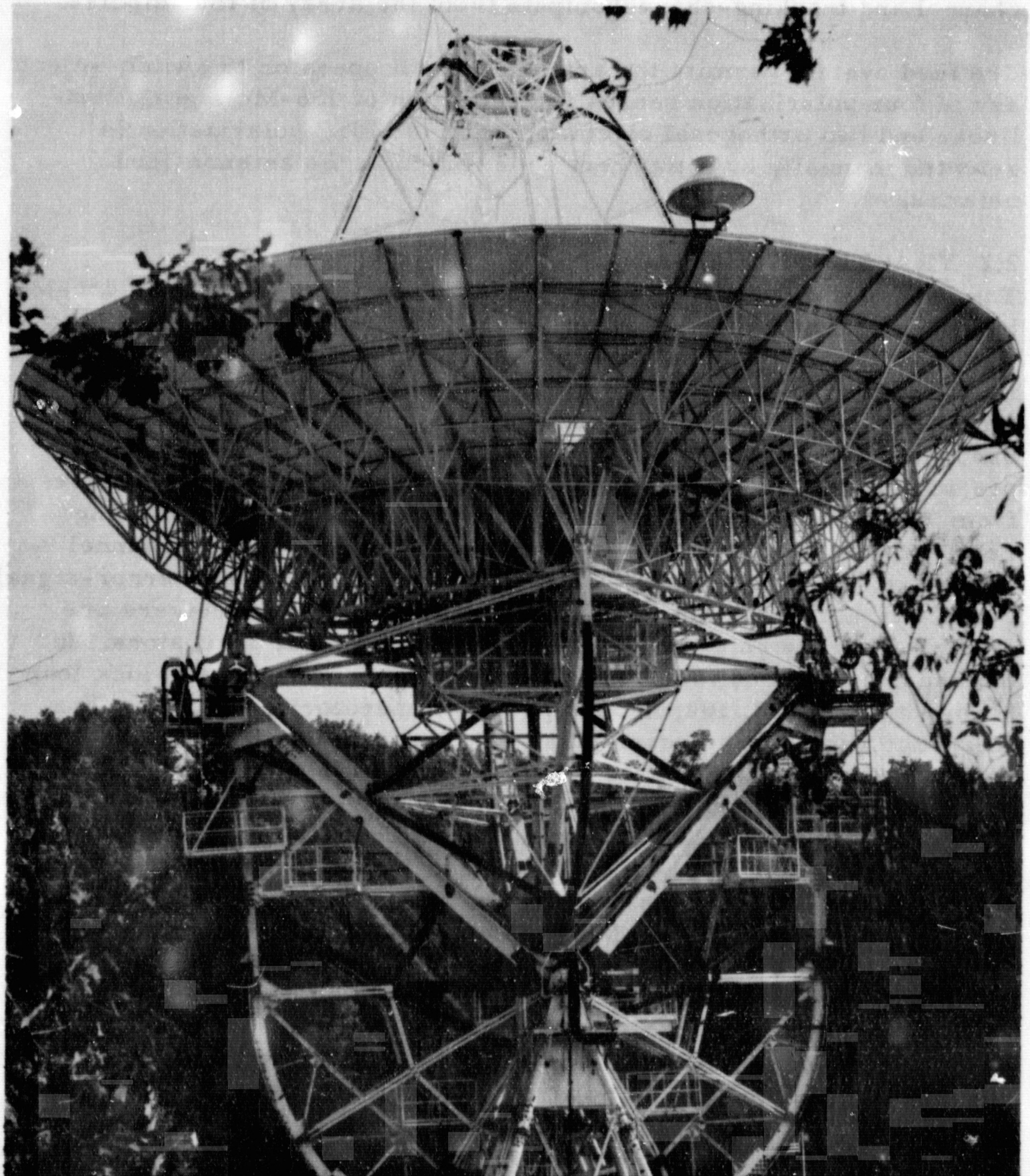


Figure V-4 – DAF 85-Foot Dish Antenna

Standard monopulse circuitry with coaxial hybrids obtains the sum-channel and tracking-channel outputs from the array of four dipoles.

The feed system permits the antenna control operator to switch-select any of four polarization senses for reception of 136-Mc signals (two linear and two orthogonal circular). At 1700 Mc, polarization is selected manually by component substitution in the antenna-feed network.

2.2 TRACKING RECEIVERS

The DAF stations have tracking receivers for the 1700-Mc and 136-Mc bands, permitting acquisition on 136-Mc and more precise tracking when the 1700-Mc Nimbus transmitter is commanded on. The 1700-Mc receiver has two modes of operation: a narrowband phase-lock mode for high-sensitivity tracking, and an open-loop mode having a wide bandwidth for tracking signals with an unstable carrier. The RF preamplifiers for 136 Mcs and 1700 Mcs as well as down converters from 1700 Mc to 136 Mc are located on the antenna. The tracking receiver actually consists of four sections: two reference-channel receivers, an X-axis error-signal receiver, and a Y-axis error-signal receiver. Local oscillators for the two error-signal receivers are derived from the reference-channel receiver's local oscillators. In the phase-lock mode, the IF bandwidth is 2 kc and the phase-lock loop bandwidth is 10, 30, 100, or 300 cps at the operator's selection. The frequency range of the received signal, about the receiver center frequency, for which the receiver can maintain lock, is at least 55 kc. The receiver is capable of functioning properly with an input signal level between - 50 dbm and threshold. The crystal-controlled tracking receiver is tunable over the 130.00-Mc to 139.99-Mc band in tuning steps of 10 kc, which gives coverage of the 1700-Mc to 1710-Mc range when coupled with the 1700-Mc/136-Mc down converter.

The 136-Mc phase-lock tracking receiver is identical to the receiver used for 1700-Mc tracking. Low-noise RF amplifiers are located in the receiver box behind the feed on the antenna, and the amplified 136-Mc signals are brought down by means of coaxial cables into the control room. The receiver is tunable over the 130.00-Mc to 139.99-Mc band in 10-kc steps. In the open-loop mode of operation, there are four selectable predetection bandwidths of 10, 30, 100, and 300 kc; in the closed-loop mode of operation, the 136-Mc tracking receiver has a predetection bandwidth of 2 kc and selectable loop band-width of 10, 30, 100 and 300 cps. Multicouplers, following the RF

preamplifiers, provide outputs feeding the 136-Mc telemetry receivers. Isolation between channels is greater than 30 db.

2.3 TELEMETRY RECEIVERS

The 1700-Mc telemetry receivers use the parametric amplifiers in common with the 1700-Mc tracking receiver. The 1700-Mc to 1710-Mc signals are converted to 130-Mc to 140-Mc signals by means of a fixed-tuned oscillator. The bandwidth of the 1700-Mc preamplifiers is 13 Mc. The 1700-Mc/136-Mc multicoupler can drive up to three telemetry receivers, independently tuned over the frequency range of 130-Mc to 140-Mc. Polarization diversity reception will be used for receiving each of the Nimbus signals in the 136-Mc and 1700-Mc bands. One diversity receiver will receive the PCM A and PCM B telemetry signals; the second diversity receiver will receive the AVCS/HRIR, and at GILMOR a third will receive the APT. The 136-Mc RF preamplifier is common to the tracking receiver and the telemetry receiver. The multicoupler following the preamplifier can supply up to four channels to the telemetry receivers. The 136-Mc telemetry receivers are tunable in 1-kc steps, and have selectable predetection bandwidths of 10 kc, 30 kc, 100 kc, 300 kc, 1 Mc, and 3 Mc. Each bandwidth has an FM discriminator output, an AM detected output, a translated IF output, and a straight IF output.

2.4 DATA SYSTEM

The data system provides for the measurement, digital encoding, and readout of the antenna shaft angles for feeding into the servosystem, visual readout, and teletype punch. These position-data and data-quality codes, punched on paper tape in five-level teletype code, can be transmitted to GSFC for orbital computation purposes. The data system includes a small computer with associated electronics which accepts the antenna drive tape 1-minute-interval predictions received by teletype from GSFC, processes the received data, and generates 1-second-interval predictions by interpolation. The data system then compares the 1-second preditions to the actual antenna positions and generates a velocity error signal for the servosystem.

2.5 COMMAND SYSTEM

The command system consists of the command transmitters and associate command antenna mounted on the rim of the 85-foot dish. The command antenna has a gain of 12 db and a power handling capacity of 3 kw.

The command transmitters have a fixed power output of 2.5 kw and a tuned position whereby the power can be varied down to 10 db below 2.5 kw. For the Nimbus program the tuned position will be set for an output of 1.0 kw. Remote monitor panels are included with each transmitter to control and monitor the operation of the transmitter in the antenna operations room. During a pass, various controls are transferred to the control of the Nimbus Command Console.

At ROSMAN a SATAN high-gain transmitting system will be used as a backup to the dish-mounted antenna and associated transmitter. The SATAN transmitting antenna has a gain of 22 db and the command transmitters have an output of 5.0 kw, 2.5 kw, and 500 w.

2.6 GILMOR ACQUISITION SYSTEM

A block diagram of the GILMOR data acquisition system is shown in Figure V-5.

2.6.1 ANTENNA POLARIZATION

136.500-Mc

Tracking - right circular

Data acquisition - both circular polarizations

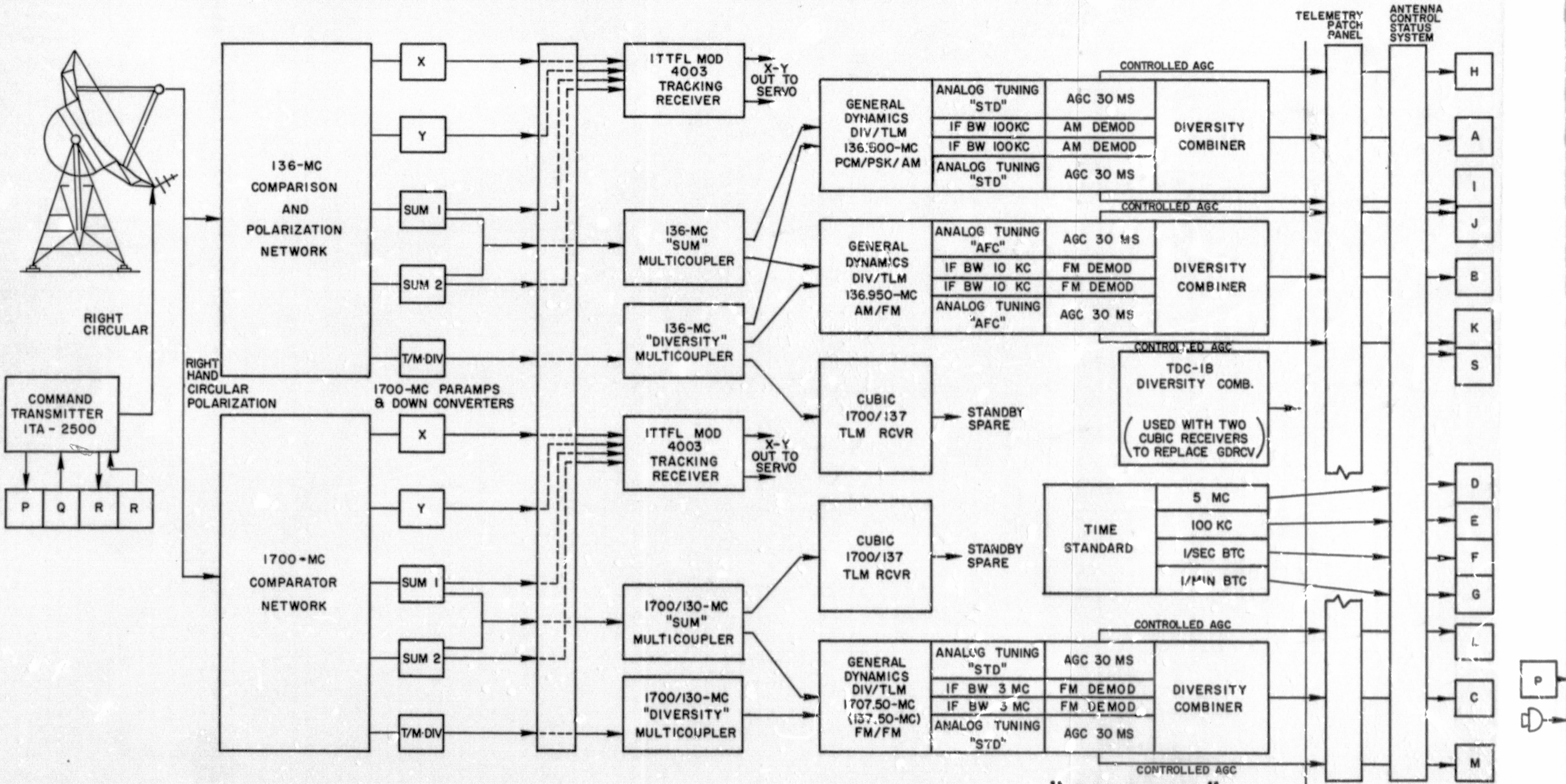
1700.000 Mc

Tracking - right circular

Data acquisition - both circular polarizations

2.6.2 DIVERSITY TELEMETRY SYSTEM 1

Frequency	- 136.500 Mc
Inputs	- output of antenna sum channel - output of antenna diversity channel
Bandwidth	- 100 kc
AGC speed	- 30 m. sec.
Analog tune selector	- STD



136-MC COMPARISON AND POLARIZATION NETWORK
RIGHT CIRCULAR
RIGHT HAND CIRCULAR POLARIZATION
COMMAND TRANSMITTER ITA - 2500
P
Q
R
R
X
Y
SUM 1
SUM 2
T/M-DIV
1700-MC PARAMPS & DOWN CONVERTERS
1700-MC COMPARATOR NETWORK
ITTFL MOD 4003 TRACKING RECEIVER
X-Y OUT TO SERVO
136-MC "SUM" MULTICOUPLER
136-MC "DIVERSITY" MULTICOUPLER
1700/130-MC "SUM" MULTICOUPLER
1700/130-MC "DIVERSITY" MULTICOUPLER
GENERAL DYNAMICS DIV/TLM 136.500-MC PCM/PSK/AM
ANALOG TUNING "STD"
IF BW 100KC
AGC 30 MS
AM DEMOD
DIVERSITY COMBINER
CONTROLLED AGC
GENERAL DYNAMICS DIV/TLM 136.950-MC AM/FM
ANALOG TUNING "AFC"
IF BW 10 KC
FM DEMOD
CUBIC 1700/137 TLM RCVR
STANDBY SPARE
TDC-1B DIVERSITY COMB.
(USED WITH TWO CUBIC RECEIVERS TO REPLACE GDRCV)
TIME STANDARD
5 MC
100 KC
1/SEC BTC
1/MIN BTC
GENERAL DYNAMICS DIV/TLM 1707.50-MC (137.50-MC) FM/FM
IF BW 3 MC
TELEMETRY PATCH PANEL
ANTENNA CONTROL STATUS SYSTEM
H
A
I
J
B
K
S
D
E
F
G
L
C
M
P

"GILMOR"

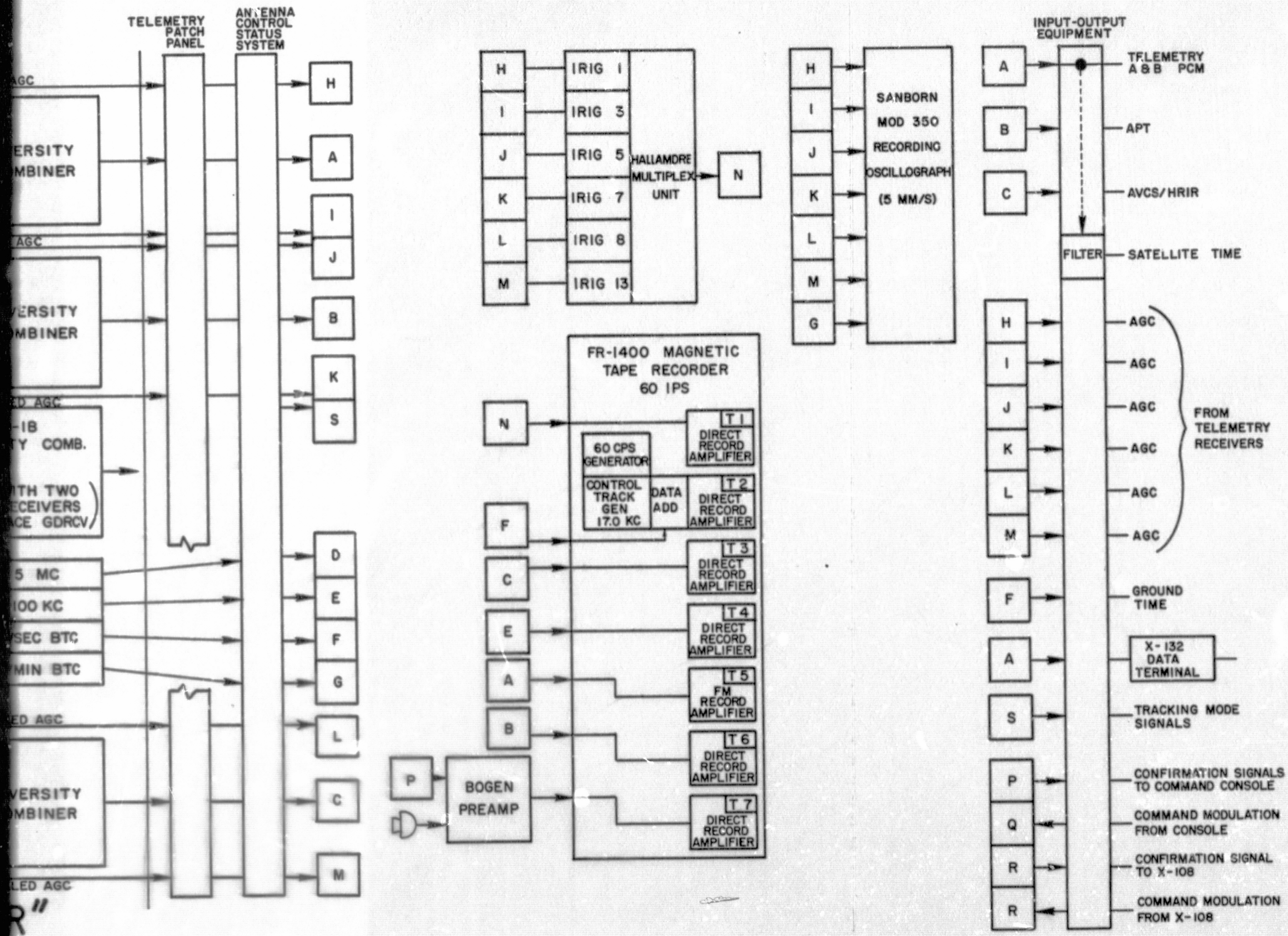


Figure V-5 – GILMOR DAF, Block Diagram

Gain control mode	- AGC
BFO function	- Off
Signal calibration output	- Off
Mode selector	- AM
Combiner output level	- 2.8 v P-P for 80% modulation

2.6.3 DIVERSITY TELEMETRY SYSTEM 2

Frequency	- 136.950 Mc
Inputs	- output of antenna sum channel - output of antenna diversity channel
Bandwidth	- 30 kc
Analog tune selector	- STD
Gain control mode	- AGC
AGC speed	- m. sec.
BFO function	- Off
Signal calibration output	- Off
Combiner output level	- 2.8 v P-P for ± 15-kc deviation

2.6.4 DIVERSITY TELEMETRY SYSTEM 3

Frequency	- 1707.5 Mc
Inputs	- output of antenna sum channel - output of antenna diversity channel
Bandwidth	- 3 Mc
Analog tune selector	- STD
Gain control mode	- AGC

AGC speed	- 30 m. sec.
BFO function	- Off
Signal calibration output	- Off
Mode selector	- FM
Combiner output level	- Set to 2.8 v P-P for ±1.5 Mc deviation

2.6.5 HALLIMORE VCO's AND SUMMATION AMPLIFIER

Inputs - AGC's from channels A and B of diversity telemetry systems 1, 2, and 3.

Output - Summed outputs of VCO's

2.6.6 SANBORN MODEL 350 RECORDER

Inputs - AGC's from channels A and B of diversity telemetry systems 1, 2, and 3.

2.6.7 FR-1400 MAGNETIC TAPE RECORDER TRACK ASSIGNMENTS
This recorder is to be set up for normal record level with 1.0 v P-P input on tracks 3, 5, 6, and 7.

Track	Record Amplifier	Source	Signal
1	Direct	Summation amplifier	Multiplexed AGC's
2	Direct	Control track generator and time standard system	60 cps on 17.0 kc and binary time code (BTC)
3	Direct	Diversity telemetry system 3	AVCS/HRIR
4	Direct	Time standard system	100 kc reference frequency

Track	Record Amplifier	Source	Signal
5	FM	Diversity telemetry system 1	Telemetry A and B
6	Direct	Diversity telemetry system 2	APT
7	Direct	Command subsystem and audio amplifier	Voice and command verification

Voice commentary should include:

Station
Date and time
Event (satellite name)
Any pertinent comments that would be helpful to the data user

2.7 ROSMAN ACQUISITION SYSTEM

A block diagram illustrating the ROSMAN data acquisition is shown in FigureV-6.

2.7.1 ANTENNA POLARIZATION

136.500 Mc

Tracking - right circular

Data acquisition - both circular polarizations

1700.000 Mc

Tracking - right circular

Data acquisition - both circular polarizations

2.7.2 DIVERSITY TELEMENTRY SYSTEM 1

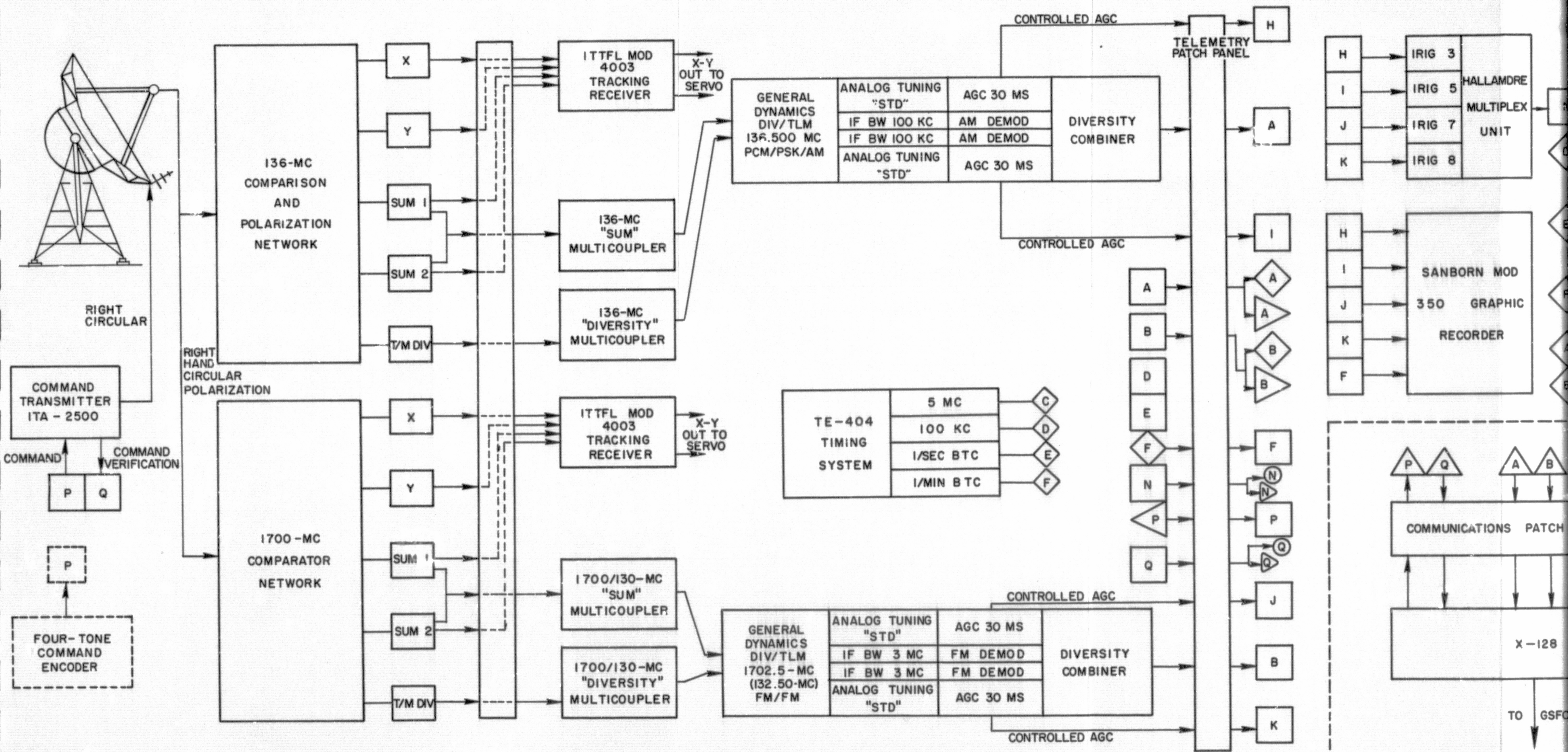
Frequency - 136.500 Mc

Inputs
- output of antenna sum channel
- output of antenna diversity channel

Bandwidth	- 100 kc
Analog tune selector	- STD
Gain control mode	- AGC
AGC speed	- 30 m. sec.
BFO function	- Off
Signal calibration output	- Off
Mode selector	- AM
Combiner output level	- Set to 2.8 v P-P for 80% modulation

2.7.3 DIVERSITY TELEMETRY SYSTEM 2

Frequency	- 1707.5 Mc
Inputs	- output of antenna sum channel - output of antenna diversity channel
Bandwidth	- 3 Mc
Analog tune selector	- STD
Gain control mode	- AGC
AGC speed	- 30 m. sec
BFO function	- Off
Signal calibration output	- Off
Mode selector	- FM
Combiner output level	- Set to 2.8 v P-P for ±1.5 Mc deviation


RIGHT CIRCULAR
COMMAND TRANSMITTER ITA - 2500
COMMAND
COMMAND VERIFICATION
P
Q
P
FOUR-TONE COMMAND ENCODER
RIGHT HAND CIRCULAR POLARIZATION
136-MC COMPARISON AND POLARIZATION NETWORK
X
Y
SUM 1
SUM 2
T/M DIV
1700-MC COMPARATOR NETWORK
ITTFL MOD 4003 TRACKING RECEIVER
X-Y OUT TO SERVO
136-MC "SUM" MULTICOUPLER
136-MC "DIVERSITY" MULTICOUPLER
1700/130-MC "SUM" MULTICOUPLER
1700/130-MC "DIVERSITY" MULTICOUPLER
GENERAL DYNAMICS DIV/TLM 136.500 MC PCM/PSK/AM
ANALOG TUNING "STD"
IF BW 100 KC
AGC 30 MS
AM DEMOD
DIVERSITY COMBINER
CONTROLLED AGC
GENERAL DYNAMICS DIV/TLM 1702.5-MC (132.50-MC) FM/FM
IF BW 3 MC
FM DEMOD
TE-404 TIMING SYSTEM
5 MC
100 KC
1/SEC BTC
1/MIN BTC
TELEMETRY PATCH PANEL
IRIG 3
IRIG 5
IRIG 7
IRIG 8
HALLAMDRE MULTIPLEX UNIT
SANBORN MOD 350 GRAPHIC RECORDER
COMMUNICATIONS PATCH
X-128
TO GSFC

"ROSMAN"

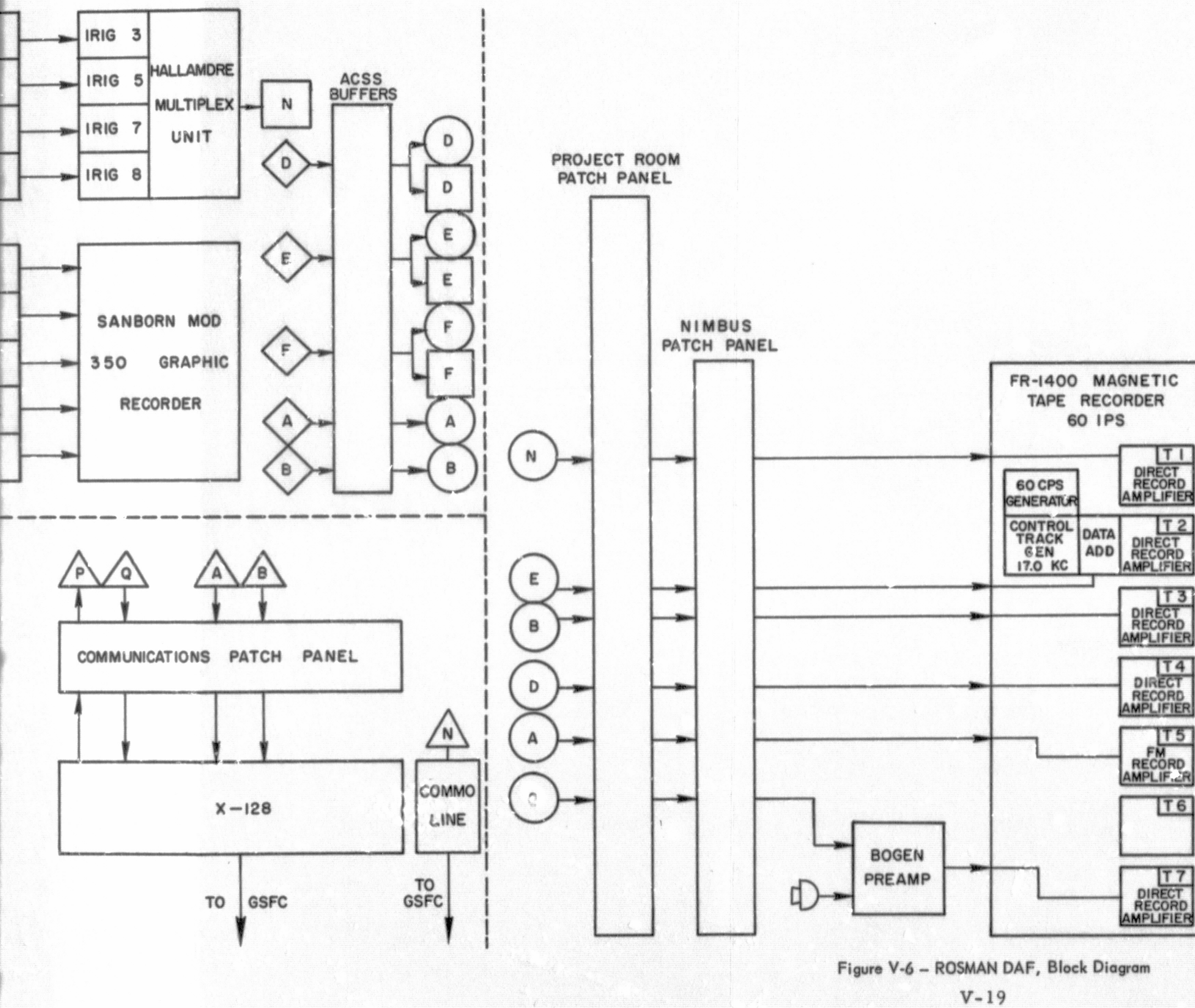


Figure V-6 – ROSMAN DAF, Block Diagram

2.7.4 HALLIMORE VCO's AND SUMMATION AMPLIFIER

Inputs - AGC/s from channels A and B of diversity telemetry systems 1 and 2

Output - Summed outputs of VCO's

2.7.5 SANBORN MODEL 350 RECORDER

Inputs - AGC's from channels A and B of diversity telemetry systems 1 and 2

2.7.6 FR-1400 MAGNETIC TAPE RECORDER TRACK ASSIGNMENTS

This recorder is to be set up for normal record level with 2.8 v P-P input on tracks 3, 5, 6, and 7.

Track	Amplifier	Source	Signal
1	Direct	Summation amplifier	Multiplexed AGC's
2	Direct	Control track generator and time standard system	60 cps on 17.0 kc and binary time code (BTC)
3	Direct	Diversity telemetry system 3	AVCS/HRIR
4	Direct	Time standard system	100 kc
5	FM	Diversity telemetry system 1	Telemetry A and B
6	Direct	Diversity telemetry system 1	Telemetry A and B
7	Direct	Command subsystem and audio amplifier	Voice and command verification

Voice commentary should include:

Station
Date and time
Event (satellite name)
Any pertinent comments that would be helpful to the data user.

2.8 JOBURG

A block diagram illustrating the data acquisition system is shown in Figure V-7. On the first orbit JOBURG will attempt to determine spacecraft spin rate by monitoring the 136.500-Mc beacon transmitter. Examination of the MOD I receiver AGC is expected to reveal the required information. Additionally, JOBURG will check the setting of the spacecraft clock by comparison with the ground station clock. The technique employed will be that of simultaneously recording the spacecraft and ground timing signals at 30 ips and then playing the signals back at 1/16 of the recording speed (1 - 7/8 ips) for display on the visicorder graphic recorder.

2.9 WNKFLD

A block diagram illustrating the data acquisition system is shown in Figure V-7. WNKFLD will attempt to determine spacecraft spin rate by monitoring the 136.500-Mc beacon transmitter and recording the AGC from the MOD I receiver on a graphic recorder.

2.10 DATA TRANSFER

Raw X-Y tracking data received by the DAF stations will be sent to NTCC for the first two weeks. Sanborn recordings will be sent daily to:

Network Operations Branch
Code 537
Goddard Space Flight Center
Greenbelt, Maryland
Attn: Network Controller

A schedule for the disposition of magnetic tapes will be sent to the DAF stations by teletype.

3. NIMBUS DATA-HANDLING SYSTEM (NDHS)

NDHS is the ground equipment that collects and processes spacecraft telemetry data and meteorological sensor data. NDHS equipment is described briefly in paragraph 3.5, below, and in detail in GE document 64SD4204, Nimbus Operations and Procedures Manual, Vol. III, Nimbus Data Handling System.

There are two NDHS sites. One is located at the GILMOR DAF station (Figure V-8); the other is in the basement of Building 3, GSFC (Figure V-9). The GILMOR NDHS is used with the 85-foot dish antenna at GILMOR. The GSFC NDHS receives raw data from the ROSMAN antenna and real-time PCM data from the GILMOR antenna system.

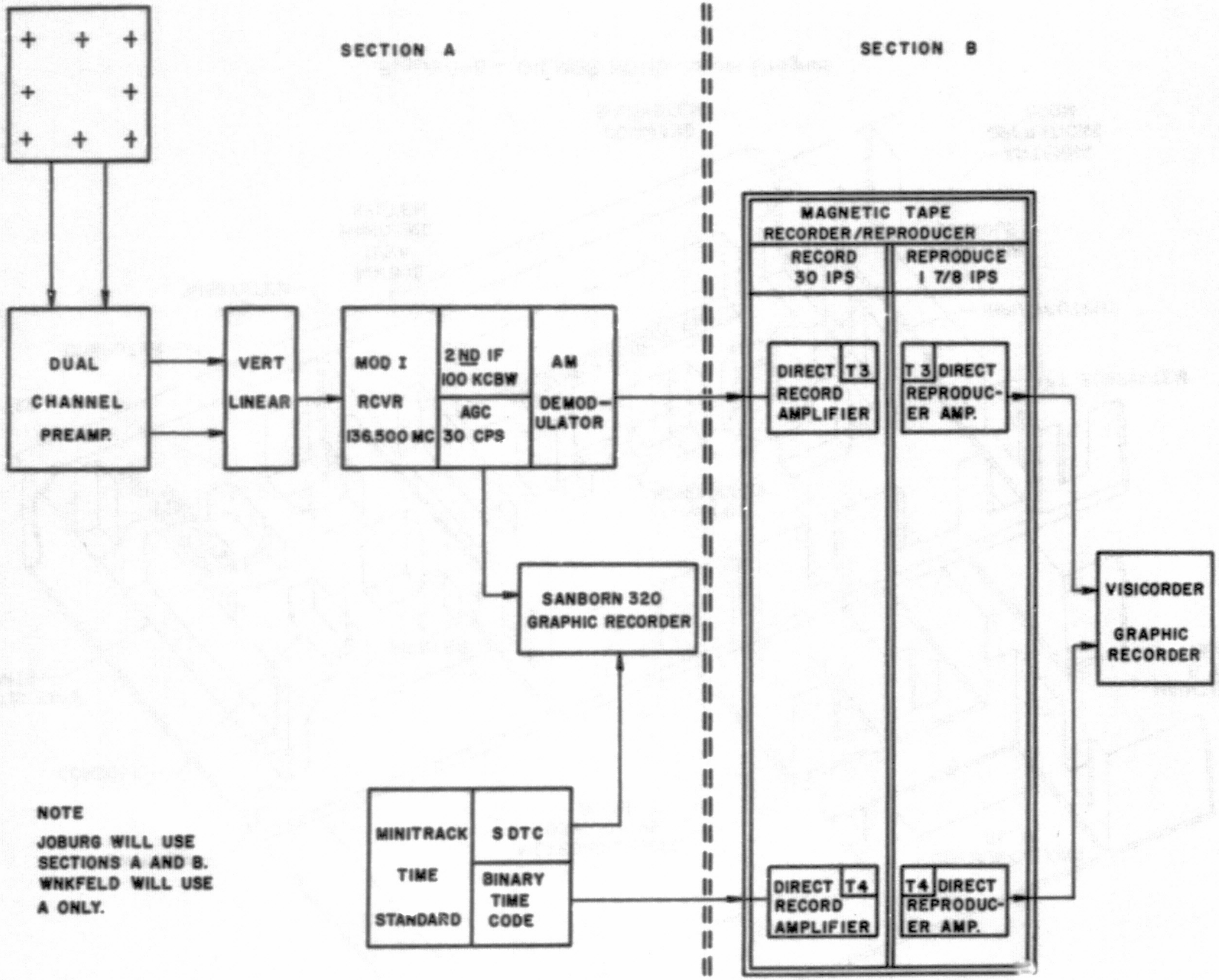


Figure V-7 – Nimbus Spacecraft Clock and Spin Rate Monitoring Configuration, JOBURG and WNKFLD

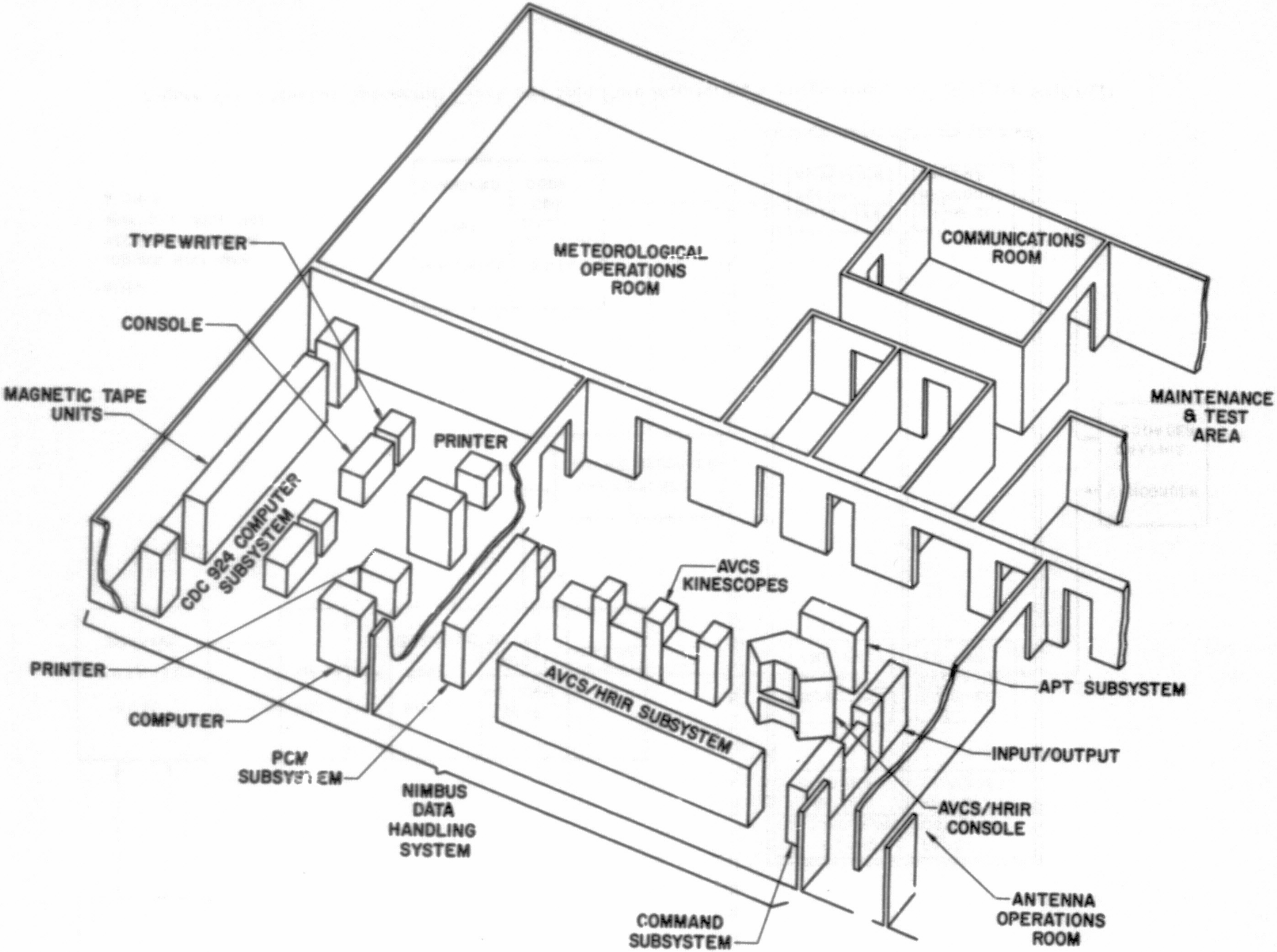


Figure V-8 – GILMOR NDHS Layout Diagram

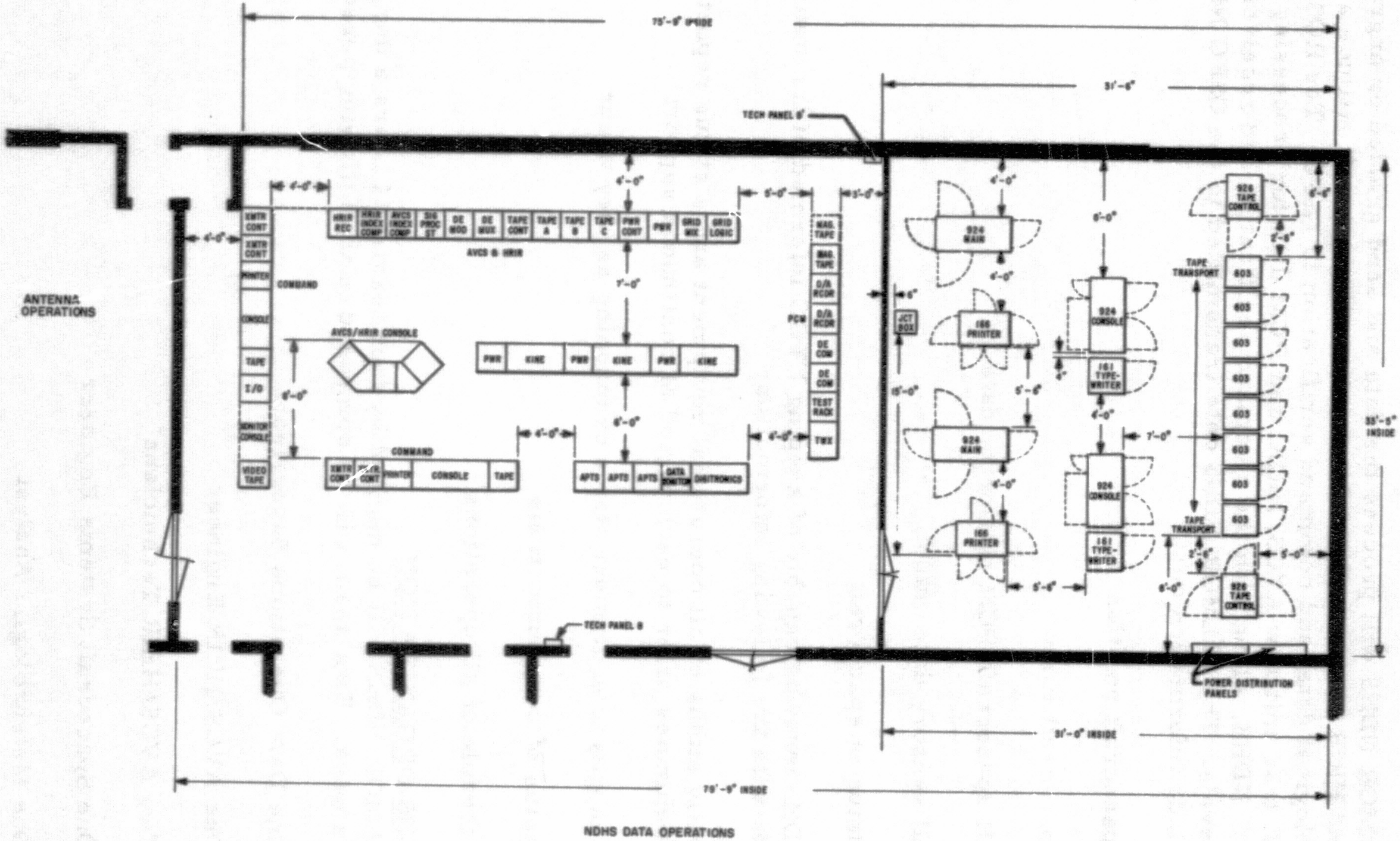


Figure V-9 – GSFC NDHS Layout Diagram

The GILMOR NDHS will process the data and send gridded or ungridded AVCS and HRIR pictures, PCM data, selected spacecraft attitude and meteorological data, and command verification to GSFC. The ROSMAN DAF will transmit raw AVCS, HRIR, and PCM data for processing at the GSFC NDHS, along with the command verification and receivers' signal levels. The GILMOR NDHS data transmitted to the GSFC NDHS will include information on:

- Spacecraft position
- Spacecraft time
- All spacecraft PCM telemetry data
- All sensory data output
- Status of spacecraft

Each NDHS must be capable of keeping NTCC informed of its status at all times with the following information:

- Daily status of all operational equipment and a status report 40 minutes prior to each period of continuous support
- Changes to equipment status or manning as they occur
- Status of communications
- Schedule of all operations

3.1 NDHS ORGANIZATION

The GILMOR NDHS will be manned by four teams, 24 hours a day, 7 days a week. Each team will be composed of the following personnel:

- One Data Operations Supervisor
- One AVCS/HRIR Engineer
- Two AVCS/HRIR Technicians
- One Spacecraft Systems Engineer
- One Meteorologist Analyst

- Two Computer Programmers
- One Command Console Operator
- Two PCM Operators
- One Systems Technician

The GSFC NDHS will have 24-hour a day, 7 days a week, operation for computer. AVCS/HRIR, and the Data Operations Supervisor. The PCM and command subsystems will be operated in 2 shifts a day, 7 days a week. The breakdown for each shift is identical to that for the GILMOR team except that there will be no Meteorological Analyst or Spacecraft Systems Engineer at GSFC.

3.2 NDHS RESPONSIBILITIES

Each staff, under the direction of the NDHS Manager, is responsible to the Nimbus Operations Manager for the operation of the NDHS site. The NDHS staff must be ready at all times to respond to the direction of the NTCC with respect to acquiring information from the spacecraft, transmitting commands to the spacecraft, processing any Nimbus data, and transmitting information to any outside agency as directed by NTCC.

The responsibilities of the NDHS are to:

- Respond to all direction from NTCC
- Receive and record data transmitted from the Nimbus spacecraft via the antenna facility
- In accordance with the spacecraft command sequence prepared by NTCC, send instructions to the spacecraft both to change the status of the spacecraft and/or to have certain data transmitted to the ground stations
- Keep NTCC informed on the status of NDHS equipment
- Process the data received from the spacecraft to the extent directed by NTCC
- Transmit operational meteorological data to USWB

3.2.1 PRE-PASS OPERATION

Prior to a spacecraft pass both the antenna system and NDHS go through a pre-pass checkout procedure to verify operational readiness of all equipment, personnel, and operational interfaces. Also, during this period the NDHS Data Operations Supervisor receives specific directions from NTCC concerning the handling of the particular pass. This supplements direction that is normally sent on a daily basis from NTCC.

3.2.2 ON-PASS OPERATION

At this point coordination of the activities of the antenna system and the NDHS is assumed by the NDHS Data Operations Supervisor and remains with him until interrogation of the spacecraft terminates. Control of the antenna system then remains with the antenna system Shift Supervisor.

During the actual pass the NDHS Data Operations Supervisor is responsible for all activities and makes all decisions relating to Nimbus at the facility. He is in voice communications with NTCC. During on-pass and post-pass operation all operator personnel are in a voice communications net through which they can monitor all operational communications in the system. The Data Operations Supervisor uses the net to exercise moment-by-moment control of data-handling operations.

3.2.3 POST-PASS OPERATION

All post-pass activity at the NDHS is under the Data Operations Supervisor's direction.

If special action is indicated through analysis of data, it must be presented to the Data Operations Supervisor who passes it on, or directs that it be passed on, to NTCC.

3.3 NDHS OPERATIONAL COMPUTER PROGRAMS

The NDHS operational computer programs consist of CDC 924 computer programs for PCM telemetry data processing and the computation of grid point coordinates. The PCM data-processing programs constitute one of the basic tools available to NTCC for spacecraft performance assessment.

3.3.1 PCM PROGRAMS

The NDHS equipment reaction time is such that processed spacecraft performance data cannot be made available at NTCC during a spacecraft pass over the GILMOR station. There still exists the possibility that spacecraft malfunctions may occur which require that corrective action be taken during the same pass in which the malfunction was

detected. A program for the real-time A telemetry will print out the status of 29 conditions of the spacecraft and a limited selection of telemetry points. This will be used for real-time verification of command execution (when possible) and for appraising the instantaneous condition of the power supply so that necessary commands can be executed to ensure the safety of the spacecraft. The stored-A telemetry data will be processed by a computer program to give an on-pass summary of spacecraft performance during the previous orbit. As soon as possible after the spacecraft pass, the meteorological data and supporting telemetry will be transmitted to GSFC. The total spacecraft performance assessment will be performed between spacecraft interrogations at NTCC. The telemetry data processing program is arranged in discrete units known as modules. Each module acts on the acquired data to perform a specific function and produce a specific computer printout.

During the spacecraft pass the on-line data module (OLDM) will be initialized in the computer. During reception of A-stored data, which consists of the telemetry data recorded by the spacecraft during the previous orbit, the OLDM will output the data in digital form on magnetic tape. During the reception of stored-A, the computer will printout changes in status of 29 different conditions; this includes items such as sensor systems, auxiliary loads, compensation loads, and individual batteries. In addition, the end-of-day and end-of-night battery voltages and temperatures will be printed out. Upon completion of A-stored data reception, the module will produce a synopsis printout and a punched paper tape of the same printout for teletype transmission to NTCC. Data on spacecraft attitude recorded throughout the orbit are extracted and output as a calibrated attitude data tape (CADT) which is used by the gridding computer for its grid point computations.

During reception of A-real-time data the computer will print out telemetry values for up to 120 preselected telemetry functions and in addition will print out the status of the 29 conditions. The functions will be listed by spacecraft subsystems and will appear in engineering units with out-of-limits conditions indicated. A similar printout indicating all 62 B-telemeter functions is provided during reception of B-real-time data. The OLDM will automatically recognize the type of data (A-stored, A-real-time) being input and initiate the proper data-processing routines.

After the spacecraft pass, the digital tape of raw data will be read into the computer by the engineering units tape module (EUTM) and all data will be limit checked, converted to engineering units, and output on a magnetic tape identified as the engineering units tape (EUT). The EUTM will also produce a sync summary printout indicating those telemetry frames in which no data are available because of failure to establish sync in the PCM ground station. A punched paper tape of this printout is also obtained for teletype transmission.

EUT's produced at the GILMOR NDHS will be transmitted to the GSFC NDHS via wideband data link for off-line processing of the data.

The program modules available for further off-line processing of the data are the spacecraft status module, the data listing module, and the means and extremes module.

3.3.1.1 Spacecraft Status Module
This module evaluates the battery and gas supply status.

3.3.1.2 Data Listing Module
This module displays function values versus time. The printout will accommodate up to ten functions per sheet. The individual values of functions on a given sheet will be printed corresponding to a given time. With each time identification there is an operational mode identification, a major frame identification and clock time (GMT) for the beginning of the major frame. The operator has the prerogative of choosing the functions and time values in any quantity. The functions selected for this format will be either those sampled once every 16 seconds or the first time slot of data sampled at a faster rate. In addition, the design of this module provides a format for listing every sample for selection times of functions sampled at a rate exceeding once every 16 seconds. Such functions, as well as time values, are selectable by the operator. Suitable time annotation is provided for identifying all samples printed. The program also provides the option of listing the data in telemetry volts rather than engineering units if this is desired.

3.3.1.3 Means and Extremes Module
This module utilizes the latest orbital A-stored data obtained during the previous acquisition period to provide for the computation and display of maximum, minimum, and average values of selected functions (all 342 or any portion thereof) for selected time intervals. The operator has the prerogative of selecting functions in any order and

specifying the time interval (master frame number at the start and end of the interval). The averaging process involves computing the arithmetic mean of several values of a given function. Capability is provided to enable each function to have its individaul time interval. Also, the program has provisions for selection of a time interval by subsystems. These provisions apply to all functions selected within the subsystem and avoids repetition of identical time interval for each function.

3.3.2 GRIDDING PROGRAMS

While one computer is engaged in the processing of PCM telemetry data the second computer is involved with the gridding process. During spacecraft transmission of AVCS and HRIR data, AVCS shutter times and HRIR start times are input to the computer. Spacecraft attitude data are extracted from the A-stored telemetry by the PCM computer and output on magnetic tape. The attitude data are then read into the gridding computer from the magnetic tape. This is used with the time data and pre-stored orbital elements data to compute spacecraft position versus time.

During spacecraft transmission, AVCS and HRIR picture data are stored on Mincom recorders. After transmission is completed, the Mincom recorders are rewound and one recorder is played back for HRIR gridding. At this time the computer outputs grid point coordinates to the GRIPE which generates gridding signals which are mixed with the picture data. Transmission of the gridded data via the wideband data link is simultaneous with the gridding process. After completion of HRIR gridding the Mincom recorder is again rewound and the gridding process is repeated for AVCS data.

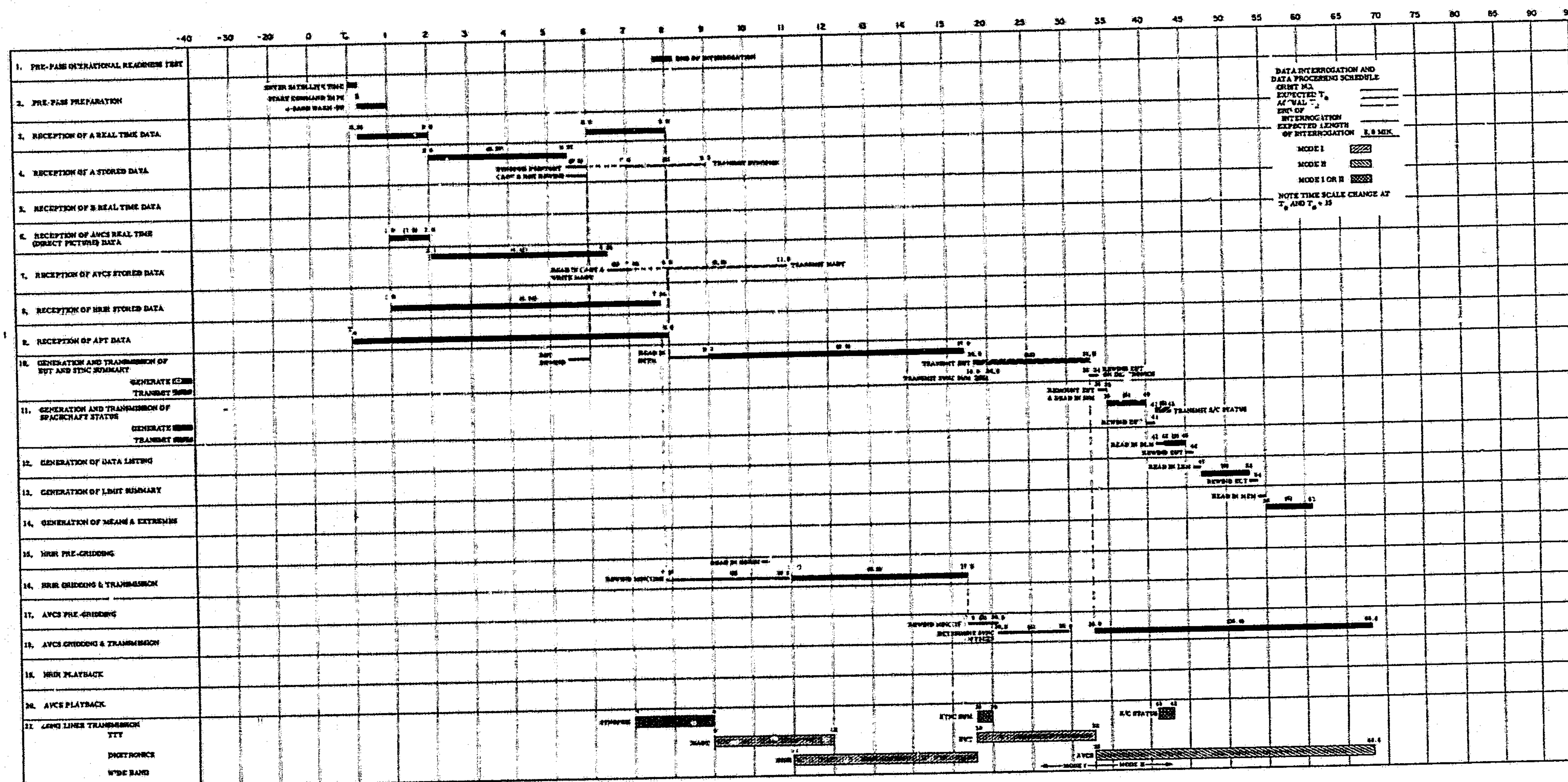
3.4 OPERATIONAL DATA HANDLING

3.4.1 SPACECRAFT DATA RECOVERY

The following paragraphs describe the basic order in which data are taken from the Nimbus spacecraft. Table V-1 is a data interrogation and processing schedule for an 8-minute period of interrogation with an 8.5-minute pass duration. Since the expected time between start-of-pass and acquisition (T_O) will be approximately 30 seconds, the 8-minute interrogation schedule can be used with a pass time of 8.5 minutes. If the pass time is other than 8.5 minutes, rearrangements and deletions of data interrogation and processing must be made. NTCC may, within the limits of equipment design, further rearrange these events in accordance with emergency conditions or special requirements.

Table V-1

Data Interrogation and Processing Schedule



3.4.2 DATA-HANDLING INPUT/OUTPUT ITEMS

Table V-2 lists the outputs of the data-handling equipment, the form in which each output is generated (film, magnetic tape, etc.); the specific piece of equipment which produces the data; and the content function and the disposition of the data items. Each item is keyed to the data flow diagram in Figure V-10; these items are referenced by number.

Figure V-11 shows which tapes are loaded on the eight CDC 603's with respect to on-line and off-line data processing.

3.4.3 DATA HANDLING EVENTS

Table V-3 lists the major data-handling events. These events are related to the input materials necessary to carry out each item and the outputs generated. A fourth column indicates which outputs are to be transmitted to NTCC and by what means the transmission should take place. The order in which the events appear in the table does not imply time sequence.

The following is a description of a typical sequence of activities performed at NDHS in association with a spacecraft interrogation. The sequence described below is an example of spacecraft interrogation by the GILMOR DAF during an 8-minute station pass when the GILMOR NDHS is operating in 2-computer mode. The pass will occur during earth day and an AVCS direct picture will be required in addition to a full orbit's worth of AVCS and HRIR data. A full orbit's worth of A-stored data will be acquired immediately after "clock-go" has been established. After A-stored playback the remaining pass time will be used to acquire A-real-time data. The interrogation profile for any given pass will be determined by the command list generated for that pass by NTCC.

3.4.3.1 <u>Preparation of Paper Tape Inputs</u>

The acquisition and processing of data during each station pass requires paper tape inputs of (1) orbital elements for the gridding program, (2) the normal station pass command list, and (3) special information for each PCM program that is to be run. Orbital elements are provided to the NDHS on a weekly basis as part of the World Map and Station Acquisition Data (WMSAD) generated by the Data Systems Division of GSFC. A paper tape of orbital elements for each station pass can be punched on the Flexowriter during blind orbit periods.

The command list paper tape is prepared by the Command Console Operator between orbits using a command list provided by NTCC.

TABLE V-2 NDHS INPUT/OUTPUT ITEMS (Sheet 1 of 4)

ITEM NO.	ITEM CODE	EQUIPMENT	DATA FORM	CONTENT	SITE USAGE	DISPOSITION
1	Video Tape	Ampex FR1400	1/2" Mag Tape	Raw video data non-demultiplexed	Recording 1700/137 Mc AVCS and HRIR data. Backup to AVCS/HRIR ground station and PCM ground station.	Mailed to Goddard NDHS Facility for detailed analysis and comparison with the Rosman video link data.
2	Tape A	AVCS/HRIR Mincom A	1" Mag Tape	Raw AVCS/HRIR or IRSA data	Playback for gridding, and/or for transmission on the wide band link	Mailed to GSFC. Archived at GSFC — source data for scientific users.
3	Tape B	AVCS/HRIR Mincom B	1" Mag Tape	Raw AVCS/HRIR or IRSA data	Playback for gridding, and/or for transmission on the wide band link	Mailed to NWSC for archiving
4	Tape C	AVCS/HRIR Mincom C	1" Mag Tape	Gridded AVCS and HRIR or IRSA data	Recording gridded AVCS/HRIR data and playback to Kines and HRIR Fax for processing or for transmission of data on wide band link	Sample tapes mailed to Goddard NDHS Facility for detailed analysis of gridding techniques and transmission characteristics.
5	Film Art	AVCS/HRIR Camera	70mm Film	Ungridded AVCS data, Left Camera	Display left camera video for real time assessment of system performance	Enter system status in log. Present to meteorological team.
6	Film Brt	AVCS/HRIR Camera	70mm Film	Ungridded AVCS data, Center Camera	Ditto for center camera	Enter system status in log. Present to meteorological team.
7	Film Crt	AVCS/HRIR Camera	70mm Film	Ungridded AVCS data, Right Camera	Ditto for right camera	Enter system status in log. Present to meteorological team.
8	Film Ag	AVCS/HRIR Kine	70mm Film	Gridded AVCS, Left Camera	Display all left camera video for analysis of gridding process	Enter system status in log. Present to meteorological team for meteorological analysis and checkout of their procedures.
9	Film Bg	AVCS/HRIR Kine	70mm Film	Gridded AVCS, Center Camera	Ditto for center camera	Enter system status in log. Present to meteorological team for meteorological analysis and checkout of their procedures.
10	Film Cg	AVCS/HRIR Kine	70mm Film	Gridded AVCS, Right Camera	Ditto for right camera	Enter system status in log. Present to meteorological team for meteorological analysis and checkout of their procedures.
11	Film IRrt	AVCS/HRIR Photo Fax	70mm Film	Ungridded IR data	Record and display HRIR and IRSA video for near real-time analysis	Enter HRIR and control system status in log. Present to meteorological team.
12	Film IRg	AVCS/HRIR Photo Fax	70mm Film	Gridded IR	Record and display all IR video for analysis of gridding process	Enter system status in log. Present to meteorological team for meteorological analysis and checkout of their procedures.
13	VSC	AVCS/HRIR Visicorder	Light sensitive paper	IR engineering data	Display HRIR and IRSA video and time signals for real-time spacecraft analysis	Enter spacecraft status in log.
14	Tape 1	PCM Mincom #1	1/2" Mag Tape	Analog PCM T/M	Playback through PCM system as required to recover data lost during real-time readout	Store until released by NTCC
15	Tape 2	PCM Mincom #2	1/2" Mag Tape	Analog PCM T/M	Backup to tape #1	Store until released by NTCC

TABLE V-2 NDHS INPUT/OUTPUT ITEMS (Sheet 2 of 4)

ITEM NO.	ITEM CODE	EQUIPMENT	DATA FORM	CONTENT	SITE USAGE	DISPOSITION
16	Raw Data Tape	Computer 1	1/2" Mag Tape	Formatted raw PCM T/M	Forms a master tape for subsequent computer routines	Stack and Store until released by NTCC
17	Gridding Record	Computer 2	Page Print	AVCS shutter times, HRIR start and stop times, AVCS corrected shutter times and attitude, error messages	Assessment of gridding operations during pregridding and gridding	File
18	PCM 'A'	PCM Brush recorders	Four 8-channel strip charts	Analog plot of up to 32 selected PCM 'A' stored or real-time parameters	Real-time engineering evaluation of the spacecraft status	Enter spacecraft status in log. Store charts until released by NTCC. Capability exists for transmitting to NTCC via Fax.
19	Spacecraft Synopsis Page	Computer 1	Page Print	Power budget and gas consumption estimates	Real-time spacecraft status check and computer generated data	Confirm printout with NTCC via SCAMA, log and hold until released by NTCC.
20	Spacecraft Synopsis Tape	Computer 1	Paper tape	Power budget and gas consumption estimates	Transmission of computer generated data to NTCC via teletype.	Present tape to communications team for transmission.
21	MADT	Computer 2	1/2" Mag tape	Calibrated formatted Attitude and Meteorological data	Spacecraft attitude, picture times, and selected telemetry points. Transmitted to NTCC and NWSC via wideband data link	Present to communications team for transmission and store until released by NTCC.
22	Engr. Units Tape	Computer 1	1/2" Mag tape	Limit checked, calibrated, functionalized, annotated PCM T/M	Transmission of all spacecraft T/M to GSFC via wideband data link	Stack, store 1 week, and erase.
23	Gridding Input Tape	Computer 2	1/2" Mag tape	Output of pre-gridding module	Store output of pre-gridding module. Input to AVCS Gridding Module and HRIR Gridding Module.	File
24	A Real Time	Computer 1	Page Print	Up to 110 functions of processed PCM 'A' real-time T/M (limit checked, calibrated and flagged)	Real time spacecraft status check. Transmission of data by voice R&D/ Backup Facility	Enter spacecraft status in log and store until released by NTCC.
25	B Data	Computer 1	Page Print	All processed PCM 'B' real-time T/M (limit checked, calibrated and flagged)	Emergency real time spacecraft status. Transmission of data by voice to R&D/ Backup Facility	Enter spacecraft status in log and store until released by NTCC.
26	EUT Sync. Summary	Computer 1	Paper tape, Page Print	Summary of all "Bad" frames of A-stored PCM T/M	Manual control of subsequent off-line computer processing of the engr. units tape. Transmission to NTCC via teletype.	Use as required for on-site off-line processing. Present paper tape to communications team for transmission.
27	Spacecraft Status	Computer 1 Computer 1	Page print and paper tape	Summary of spacecraft power budget and gas status	Assessment of spacecraft between interro. from off-line subroutines. Prep. punch paper tape for trans. of data via TTY to NTCC	Enter spacecraft status in log. Present tape to communications team for transmission of data to NTCC. Store until released by NTCC.
28	APT 1&2	Mufax facsimile	Fax paper	APT video	Evaluation of spacecraft operation	Present #1 to meteorological team for analysis and mail #2 to NTCC.
29	*Events	Event recorder	Strip Chart	Time annotated ground station events	Rapid location of ground station difficulty during data processing sequence.	Log difficulties and mail to NTCC for status correlation.

*May not be used

TABLE V-2 NDHS INPUT/OUTPUT ITEMS (Sheet 3 of 4)

ITEM NO.	ITEM CODE	EQUIPMENT	DATA FORM	CONTENT	SITE USAGE	DISPOSITION
30	*Voice Tape	Monitor Console	Magnetic Tape	Voice communications during spacecraft interrogations	Operational sequencing	Mail to NTCC for status correlation.
31	Command Strip	Command	Printed Strip	Actual commands, sequence and time	Check of spacecraft commands transmitted, sequence and time	Log one copy of printout and mail one copy to NTCC.
32	Pass Summary	Manually Prepared	Page Print	Manually prepared summary of the performance of each interrogation including spacecraft command changes	Transmission of interrogation performance to NTCC via teletype and historical record of stations operations	Present to communications team for transmission via fax. File page prints for future reference.
33	Nephs	Alden Fax Manually Prepared	Fax Paper	Nephanalysis prepared by Met Team	For transmission to NTCC and NWSC	Present to communications team for transmission via Alden Fax.
34	AVCS Pictures	Kinescope	Individual frames of AVCS	Individual frames of AVCS pictures	For transmission of AVCS pics to NTCC and NWSC	Present to communications team for transmission via Westrex Fax.
35	*Daily Report	Computer 1 or 2	Page Print and 1/2" Mag tape	Equipment status	Historical record and for transmission to GSFC Backup Facility via Wideband Link	Retain page print, present tape to communications team for transmission.
36	BCD Tape	Computer 1	1/2" Mag Tape	All printer inputs from computer #1.	Backup for printer	File
37	CADT	Computer 1	1/2" Mag Tape	Calibrated att. data and selected metro parameters	Input to pre-gridding module	File
38	B Data (raw)	Teletype Paper Punch	Page Print Paper Tape	All B data All B data	Real time B data readout Transmission to NTCC	File Transmit to NTCC on request
39	Data Listing	Computer 1	Page Print	Limit checked, calibrated PCM A-stored data. Up to 10 functions per listing.	Near RT assessment of spacecraft	File
40	Limit Summary	Computer 1	Page Print	Summary of out-of-limit conditions of selected A-stored parameters	Near RT assessment of spacecraft	File
41	Means and Extremes Summary	Computer 1	Page Print	Maximum, minimum, and mean value of selected A-stored PCM data	Near RT assessment of spacecraft	File
50	Command Input	Command Paper Punch	Paper Tape	Commands to be transmitted	Read into command modulator	File
51	System Tape	Computer 1 or 2	1/2" Mag Tape	Complete data tables and programs for computers 1 and 2	Information source to computers 1 and 2	Amend as required. File
52	PREGM	Flexowriter**	Paper Tape	Call-in, orbital elements	Operation of Pre-gridding Module	File
53	OLDM	Flexowriter**	Paper Tape	Call-in, special inputs	Operation of On-Line Data Module	File
54	EUTM	Flexowriter**	Paper Tape	Call-in, special inputs	Operation of Engineering Units Tape Module	File

*May not be used
**Parameters required by items 52-60 can be input by computer typewriter instead of paper punch tapes

TABLE V-2 NDHS INPUT/OUTPUT ITEMS (Sheet 4 of 4)

ITEM NO.	ITEM CODE	EQUIPMENT	DATA FORM	CONTENT	SITE USAGE	DISPOSITION
55	SSM	Flexowriter**	Paper Tape	Call-in, special inputs	Operation of Spacecraft Status Module	File
56	DLM	Flexowriter**	Paper Tape	Call-in, special inputs	Operation of Data Listing Module	File
57	LSM	Flexowriter**	Paper Tape	Call-in, special inputs	Operation of Limit Summary Module	File
58	AEM	Flexowriter**	Paper Tape	Call-in, special inputs	Operation of Averages and Extreme Module	File
59	AGRIM	Flexowriter**	Paper Tape	Call-in, special inputs	Operation of AVCS Gridding Module	File
60	HGRIM	Flexowriter**	Paper Tape	Call-in, special inputs	Operation of HRIR Gridding Module	File

**Items 52-60 can be input by computer typewriter instead of paper punch tapes

SUMMARY OF INPUT/OUTPUT ITEMS

TRANSMITTED	MAILED TO GSFC	USED ON SITE	MAILED TO NWSC
Tape C Data	Video Tape	Tape A	Tape B
Spacecraft Synopsis Tape Data	Tapes A & C	Tape 1 and 2	
Att and Met Tape Data	Events	Raw Data Tape	
Engineering Units Tape 1 Data	Voice Tape	Gridding Record	
Sync Summary	Command Strip	PCM "A"	
Spacecraft Status	APT #2	Spacecraft Synopsis Page	
Pass Summary	PCM "A"	Att and Met Data Tape	
Nephs (backup)	PCM Raw	Computer Output Storage Tape	
Pixs (backup)	Data Tape	A-Real Time	
Daily Report	Met. & Att.	B Data	
PCM "A" (backup)		Pass Summary	
B Data (raw)		Daily Report	
		BCD Tape	
		CADT	
		B Data (raw)	
		Data Listing	
		Limit Summary	
		Means and Extremes Summary	
		All Material Transmitted from NTCC	

*Storage of tapes is required until all data have been received, processed, and verified at GSFC.

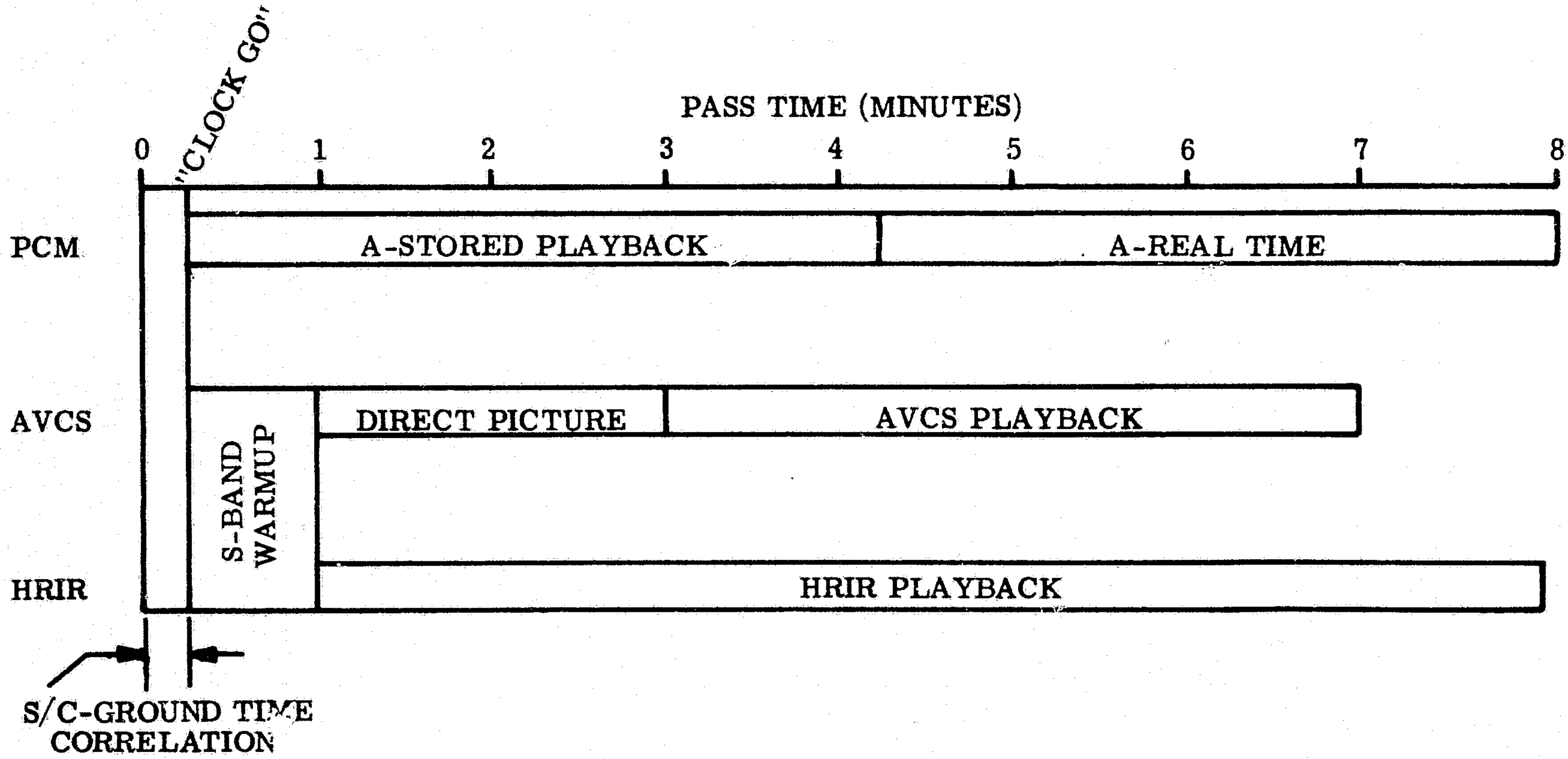


Figure V-10 – Typical Interrogation Profile

ON LINE	System Tape (51)	BCD Tape (36)	Raw Data Tape (16)	NOT USED	System Tape (51)	Gridding Input Tape (23)	Attitude and Metro Tape (21)	*Calibrated Attitude Data Tape (37)

*Input comes from Computer #1

← Computer #1 → | ← Computer #2 →

OFF LINE	System Tape (51)	BCD Tape (36)	Raw Data Tape (16) DLM Scratch Tape	Engineering Units Tape (22)	System Tape (51)	Gridding Input Tape (23)	NOT USED	Calibrated Attitude Data Tape (37)

Figure V-11 – CDC 306 Tape Loading

Table V-3
Data Handling Events

EVENTS	INPUTS*	OUTPUTS	NTCC/NDHS DATA TRANSMISSION
Pre-Pass			
Pre-pass operational readiness test			
Pre-pass preparation (check supplies & controls, prepare tapes, etc.)			
During and Following Station Pass			
PCM A-RT	OLDM 53 PCM rec'r.	Page print 24 BCD 36	
PCM A-Stored	OLDM 53 PCM rec'r.	Raw data tape 16 Synopsis page print 19 Synopsis paper punch tape 20 BCD 36 Calibrated attitude data tape 37 A&M** Tape 21	Synopsis 20 via TTY Mode I or II, Gp. II A&M**Tape 21 via Digitronics Mode I, Gp. II
PCM B-RT	OLDM 53 PCM rec'r.	Page Print 25, Paper punch tape 38 TTY Hard copy 38, BCD 36	Paper punch tape 38 via TTY Mode I or II, Gp. II.
AVCS AVCS RT	PREGM 52 AVCS/HRIR rec'r	70 mm film 5 6 7	
AVCS AVCS Stored	PREGM 52 AVCS/HRIR rec'r	70 mm film 5 6 7	
HRIR HRIR Stored	PREGM 52 AVCS/HRIR rec'r.	Photofax recorder 11 Visicorder 13	
APT APT	APT rec'r.	Mufax paper 28	
Generate EUT, Sync Summary and Transmit	EUTM 54 Raw data tape 16	Engineering units tape 22 Sync summary paper tape 26 Page Print 26	Engineering units tape 22 via Digitronics Mode I Gp II Sync summary paper tape 26 via TTY Mode I or II Gp II
S/C Status	SSM 55 EUT 22	Paper punch tape 27 Page print 27 BCD 36	S/C status paper tape 27 via TTY Mode I or II Gp II
Data Listing	DLM 56 EUT 22	Page Print 39 BCD 36	
Limit Summary	LSM 57 EUT 22	Page Print 40 BCD 36	
Means and Extremes	AEM 58 EUT 22	Page Print 41 BCD 36	
HRIR Pre Gridding	PREGM 52 CADT 37 HRIR Start time from GRIPE	A&M** tape 21 Gridding input tape 23 Page print 17	A&M** tape 21 via Digitronics Mode I Gp II
HRIR Gridding and Transmission	HGRIM 60 Mincom A or B 2 3 Gridding input tape 23	Mincom C 4 Page print 17	HRIR gridded video and time Mode I Gp I
AVCS Pre Gridding	PREGM 52 CADT 37 AVCS shutter times from GRIPE	A&M** tape 21 Gridding input tape 23 Page print 17	A&M** tape 21 via Digitronics Mode I Gp II
AVCS Gridding and Transmission	AGRIM 59 Mincom A or B 2 3 Gridding input tape 23	Mincom C 4 Page print 17	AVCS gridded video and time Mode II Gp I & II
HRIR Playback	Mincom C 4	Gridded 70 mm film 12	
AVCS Playback	Mincom C 4	Gridded 70 mm film 8 9 10	

*The System Input Tape 51 is an input requirement for all computer data processing.
**The A&M data tape 21 contains attitude and meteorological data from the CADT 37. It also contains AVCS shutter times. Therefore, it cannot be written until CADT 37 and AVCS shutter times have been input.

NOTE: The outputs of the PCM receiver, the AVCS/HRIR receiver, and the APT receiver are recorded on an FR 1400 tape recorder 1 as they are received at the input/output rack. In addition, the PCM signal is recorded on Mincom recorders 14 15, and the AVCS/HRIR demultiplexed (but not demodulated) signals are recorded on Mincom recorders 2 3.

Command lists will be provided by NTCC on a daily basis; however, the command list may be modified by voice or teletype instruction as a result of between-orbits analysis of the data at NTCC.

Paper tape inputs of special information for the PCM program are prepared on the Flexowriter on an orbit-to-orbit basis. The specific information for each module is transmitted by NTCC (already formatted for input to the computer). Paper tape input to the OLDM is prepared prior to the station pass, while inputs to the off-line modules are prepared prior to the running of each module.

The orbital sequence of activities begins at about 25 minutes before spacecraft acquisition, at which time NTCC provides the Data Operations Supervisor with the special computer input information for the next pass and any modifications to be made to the command list. The Data Operations Supervisor, in turn, relays this information to the appropriate operator personnel for the preparation of the paper tapes.

3.4.3.2 Pre-Pass Readiness Test

A pre-pass readiness check of the NDHS equipment, lasting about ten minutes, is run prior to the spacecraft acquisition (if sufficient time is available). The test starts at about 20 minutes before acquisition when the Data Operations Supervisor alerts all station personnel to begin the pre-pass readiness test. At this time all NDHS operator positions and the antenna portion of the DAF are linked together by a voice communications net. The test is completed about 10 minutes prior to the expected time of spacecraft acquisition. The Data Operations Supervisor then reports station readiness to the NTCC via SCAMA. At this time one of the SCAMA lines from GSFC is connected to the NDHS communications net, allowing both NTCC and the GSFC NDHS Data Operations Supervisor to monitor the GILMOR internal voice communications.

Just prior to expected spacecraft acquisition the paper tapes of orbital elements and OLDM special information are read into the computers.

3.4.3.3 Spacecraft-Ground Time Correlation

As soon as the spacecraft beacon signal is of sufficient strength to interrogate the spacecraft, both the spacecraft time and the ground time are entered into the command console. The console then prints out both the spacecraft time and the ground station time for comparison by the operator. When time correlation (T_o) has been established the operator

begins transmission of the command list to the spacecraft. The T_o condition is established about 15 seconds after initial spacecraft acquisition.

3.4.3.4 On-Pass PCM Data Handling

Immediately after T_o the spacecraft is commanded to play back A-stored data. The received data are recorded by the Ampex FR 1400. The PCM subsystem provides analog brush strip chart recordings of 32 selected telemetry functions.

The PCM subsystem outputs the data to a computer which, in turn, writes a magnetic tape containing all A-stored data in digital form and a magnetic tape of calibrated spacecraft attitude data for the entire orbit, which is used as input to the gridding program. After all A-stored data have been received the computer outputs the synopsis printout. The synopsis is available about 4.3 minutes after initial acquisition.

After completion of A-stored data transmission, the spacecraft is commanded to transmit A-real-time data for the remainder of the interrogated period. Thirty-two selected functions of A-real-time data can be displayed by the brush recorders while 120 selected functions can be limit checked, functionalized, and printed in engineering units by the computer at the rate of about 16.4 seconds per frame. The data are also recorded in analog form by the PCM Mincom recorder.

3.4.3.5 On-Pass Meteorological Data Handling

Immediately after clock-go has been established, the S-band transmitter is turned on by command from the ground. After 45 seconds a warmup the S-band transmitter is commanded to transmit AVCS and HRIR data. All received AVCS and HRIR data are recorded by the Ampex FR 1400 video recorder as they are input to NDHS for processing.

Immediately following S-band warmup the spacecraft is commanded to transmit HRIR data from the spacecraft tape recorder which are recorded by Mincom recorders A and B, processed on-line, and recorded on 70-mm filmstrip. Approximately 20 minutes is required for photographic processing before the film data are accessible. HRIR start times are input to the computer via the GRIPE for the computation of grid points. Immediately following S-band warmup the spacecraft is also commanded to transmit AVCS pictures stored on the spacecraft tape recorder. Data transmission from one orbit requires approximately four minutes. The AVCS data are recorded by Mincoms A and B and

processed on-line as 70-mm filmstrips photographically processed in 1 1/2 minutes (one strip per camera). AVCS shutter times are extracted and input to the computer via the GRIPE for the computation of grid points.

Direct AVCS pictures taken over the acquisition area can also be transmitted from the spacecraft by special commands.

The PCM computer outputs a calibrated attitude data tape (CADT) during reception of A-stored telemetry. The CADT is, in turn, read into the gridding computer where these data are used to correct the grid point calculations to reflect spacecraft attitude errors. The gridding computer also uses the attitude data to write a smoothed attitude and meteorological data tape (MADT) which is mounted on the tape-to-tape transport and transmitted to GSFC via the wideband data link. Transmission of the attitude and meteorological data tape is completed at about 15 minutes after spacecraft acquisition.

3.4.3.6 Post-Pass PCM Data Handling

Off-line processing of PCM A-stored data is begun at the end of the interrogation period, starting with the reduction of the entire A-stored record to engineering units. The magnetic tape output, the EUT produced at GILMOR, is then mounted on the tape-to-tape transport and transmitted to the GSFC NDHS via wideband data link. The transmission of the EUT takes place from about 17.5 minutes after initial spacecraft acquisition to about 32.5 minutes after acquisition.

Further off-line processing of the PCM data is performed at the GSFC NDHS. The sequence and timing of this off-line PCM processing will depend upon the requirements established by NTCC for the particular interrogation. The bulk of the off-line PCM processing can be completed within an hour after initial spacecraft acquisition, thereby allowing NTCC to accomplish spacecraft assessment on an orbit-to-orbit basis.

3.4.3.7 Post-Pass Meteorological Data Handling

After all AVCS and HRIR data are received, Mincoms A and B are rewound. Mincom A is then played back for HRIR gridding. As the HRIR data are gridded they are transmitted via the wideband data link to the GSFC NDHS where they are recorded and simultaneously processed as a 70-mm filmstrip. The gridded pictures are simultaneously recorded at the GILMOR NDHS by Mincom C. HRIR gridding and transmission are completed at about 18 minutes after spacecraft acquisition.

During HRIR gridding, a portion of the tape on Mincom B is played back to determine AVCS horizontal and vertical sync offsets. The offset values are then relayed by intercom to the gridding computer operator who enters this information into the computer by means of the console typewriter keyboard. Mincom B is then rewound to be used later for AVCS gridding.

After completion of HRIR gridding there is approximately a 14.5-minute wait in the data-handling sequence. This is the result of the wideband data link being occupied by the transmission of the engineering units tape which must be completed before the data link can be switched to the AVCS mode.

AVCS gridding and transmission begins at about 32.5 minutes after acquisition and continues to about 64.5 minutes after acquisition. The gridded AVCS pictures are recorded at GILMOR by Mincom C. The transmitted data are recorded at the GSFC NDHS and then played back into the kinescope in real time for the processing of gridded AVCS filmstrips. Thus the AVCS pictures are available for examination by NTCC at about 72 minutes after acquisition.

The AVCS data recorded by Mincom C at GILMOR can be played back into the kinescopes for on-site processing of gridded AVCS pictures.

3.5 NDHS EQUIPMENT

As shown in Figures V-12 through V-17, NDHS equipment includes PCM ground station equipment, AVCS/HRIR ground station equipment grid point equipment (GRIPE), a command subsystem, and two CDC 924 computers.

3.5.1 PCM SUBSYSTEM

The PCM ground station receives, processes, records, and displays PCM telemetry signals from the spacecraft. The subsystem performs the following specific functions:

- Detects incoming Minitrack time code which turns on a Mincom analog tape recorder.
- Receives and tape records incoming data.
- Detects, demodulates, and decommutates the incoming data.

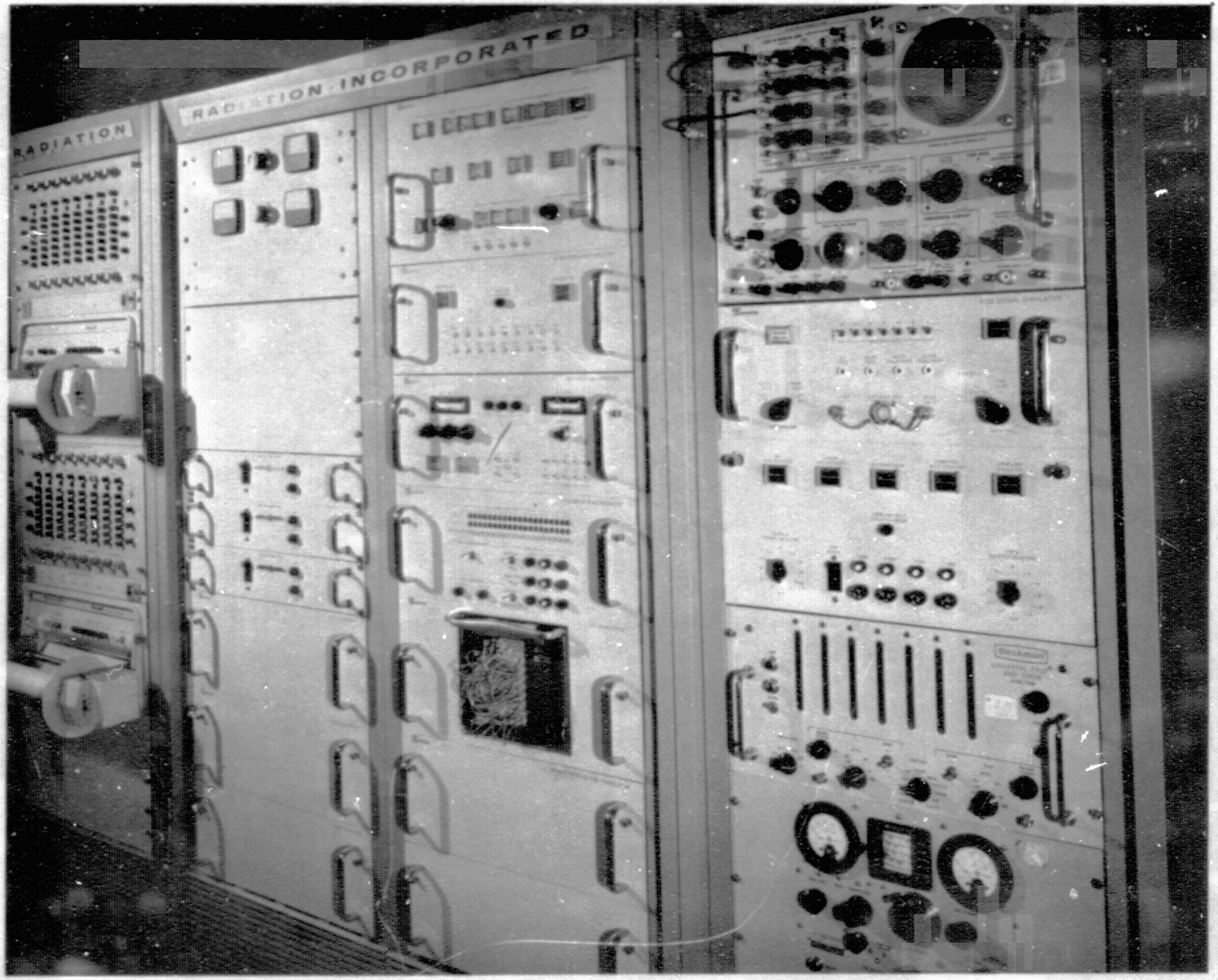


Figure V-12 – PCM Subsystem

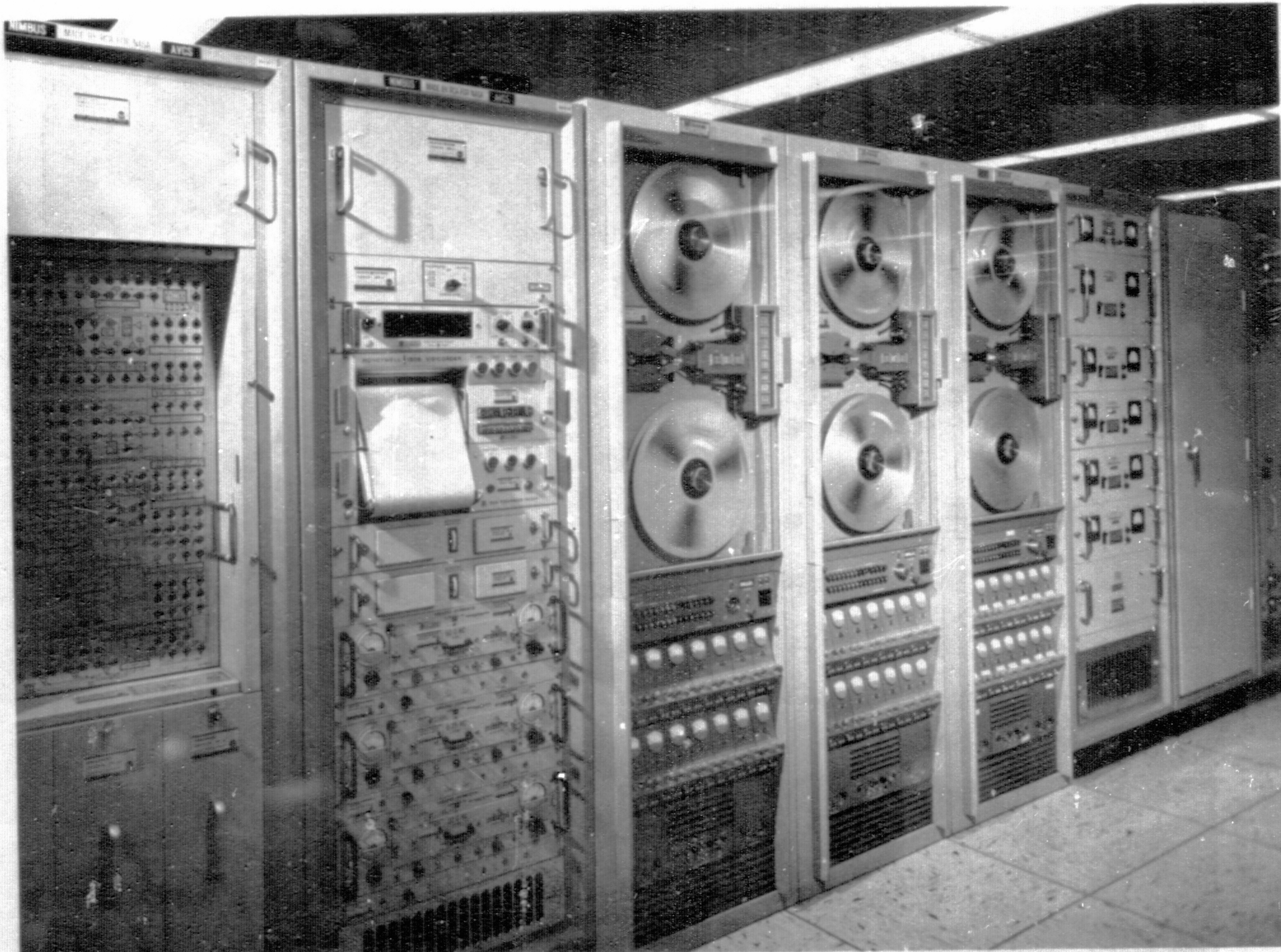


Figure V-13 – AVCS/HRIR Signal Processing Equipment, View 1

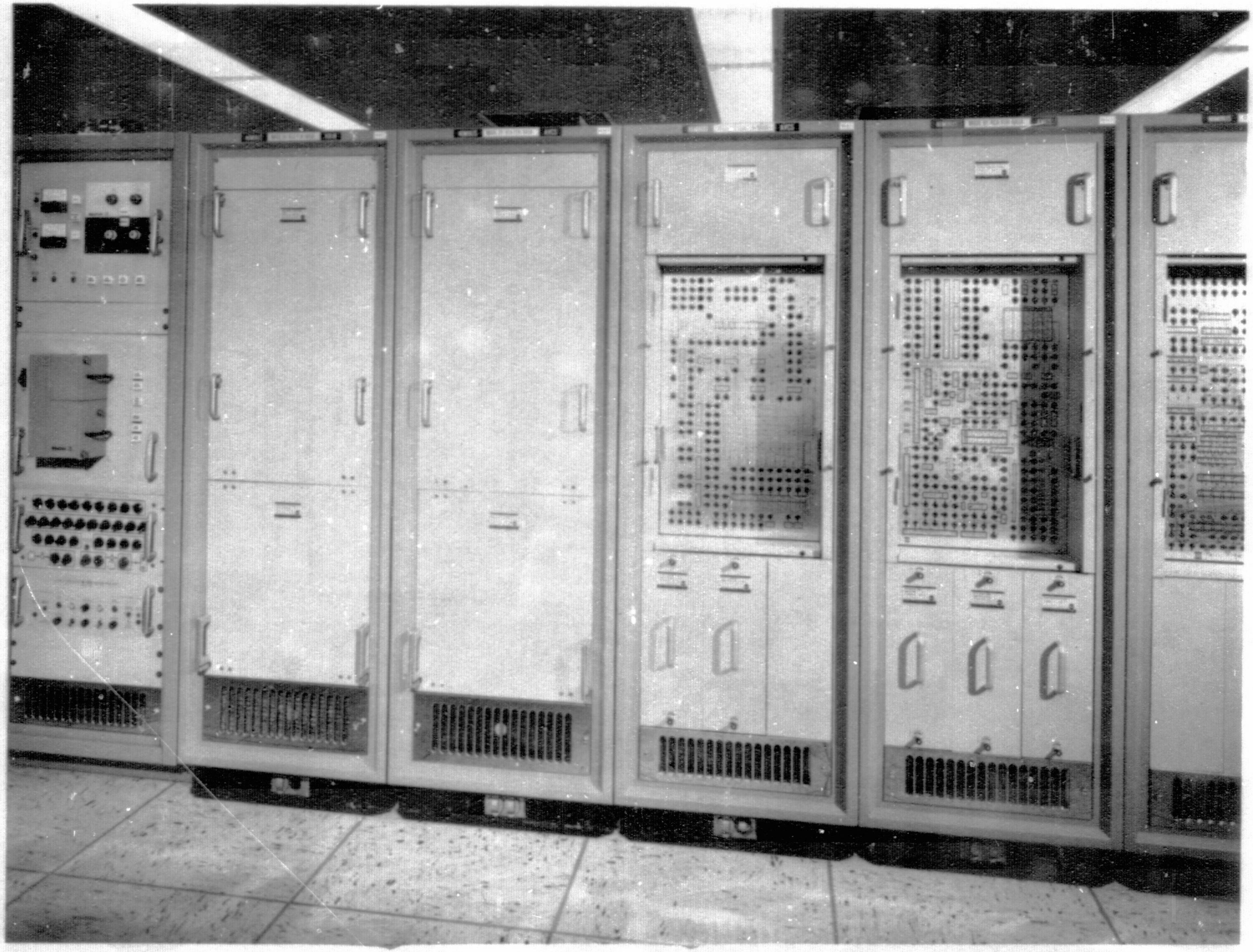


Figure V- 14 – AVCS/HRIR Signal Processing Equipment, View 2

Figure V-15 – Kinescope Assemblies

Figure V-16 – Data Processing Equipment

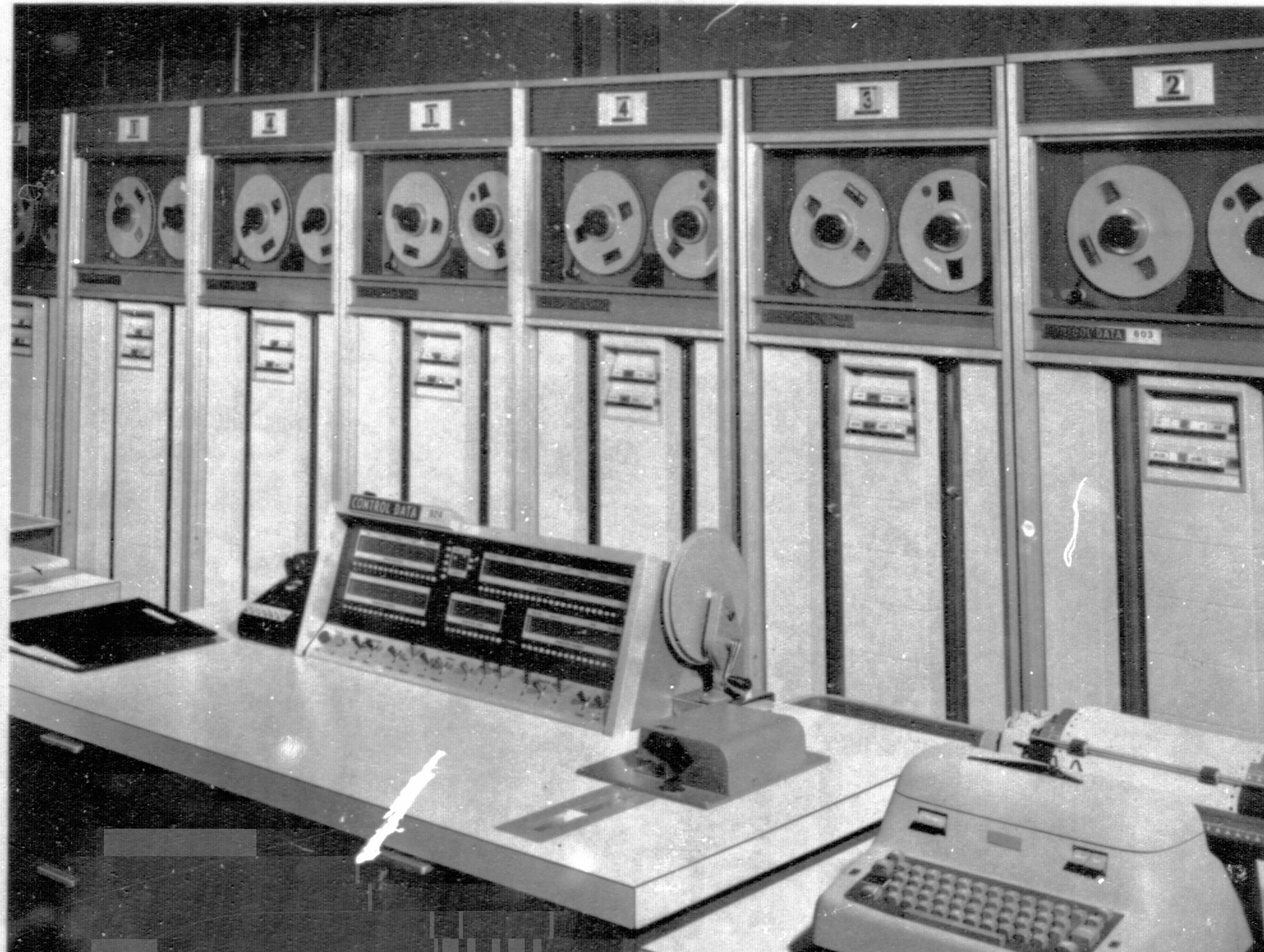


Figure V-17 – 924 Computer Tape Decks and Consoles

- Receives and processes raw data in three modes of operation. These modes are designated A-stored data, A-real-time data, and B-real-time data.
- Formats and outputs the data to a computer.
- Displays up to 32 A-stored or A-real-time telemetry functions on oscillograph recorders. The specific functions are selectable by patchboard programming.
- Displays the 62 B-real-time functions as a teletype printout.

3.5.2 AVCS/HRIR SUBSYSTEM

The AVCS/HRIR data processing equipment acquires, processes, and stores the meteorological data. The AVCS/HRIR equipment is a frequency-modulated signal (0 kc to 750 kc) made up of eight subcarriers. The signal is received from the Nimbus vehicle via the 1700-Mc receiving system. The AVCS/HRIR system supplies outputs for transmission over a wideband data link. These outputs consist of gridded or non-gridded kinescope pictures of daytime cloud cover taken by the AVCS subsystem and infrared facsimile pictures of nighttime cloud cover (also gridded or non-gridded), taken by the HRIR system. The system also provides for the tape recording of input and output data by means of Mincom analog recorders.

3.5.3 GRID POINT EQUIPMENT (GRIPE)

The GRIPE facilitates the generation of the conventional latitude and longitude grids and the electronic superposition of these grids on the cloud-cover pictures. During transmission of the data from the spacecraft the GRIPE receives AVCS shutter times and HRIR start times from the AVCS/HRIR subsystem and outputs this time data to a CDC 924 computer. The computer uses these data along with orbital elements and spacecraft attitude data to compute the grid point coordinates. After spacecraft transmission, the computer inputs the grid point coordinates to the GRIPE which generates grid point signals. These signals are then electronically mixed with the AVCS and HRIR video signals. The mixed signals are output by the AVCS/HRIR subsystem for transmission over the wideband data link and/or recording for later kinescope or facsimile processing. The wideband data link transmission of the signal can be simultaneous with the gridding process.

3.5.4 COMMAND SUBSYSTEM

The command subsystem provides the capability to transmit both encoded and unencoded commands to the spacecraft when it is in view of the DAF. The encoded commands can be punched on paper tape prior to the spacecraft pass and transmitted from the tape after acquisition is made. Both coded and unencoded commands can also be transmitted directly from the command console keyboard during the pass. The spacecraft has the capability to store up to five encoded commands for execution at a future time. The command subsystem decodes the Minitrack time modulation on the beacon and real-time-A signals. This is required for commanding the spacecraft. The command subsystem also provides the capability for resetting the spacecraft clock by command from the ground.

The PCM receiver's signal level is monitored on the command console to serve as an indicator that the spacecraft is in range to be commanded safely.

3.5.5 CDC 924 COMPUTERS

Two CDC 924 computers are provided for PCM data processing and grid point computations. Associated with each computer are a line printer, a tape control unit, four tape decks, a console typewriter, and a paper tape reader and punch. The two computer configurations are identical and either computer can be connected to both the PCM and GRIPE equipment. The computer programs are designed so that a single computer can perform both PCM data processing and grid point computation in the event of a failure in the other computer.

The GSFC NDHS is also equipped with a card punch, a card reader, and a CDC 160A computer for off-line processing of PCM data.

4. USWB DAF-ASSIGNED METEOROLOGICAL TEAM AT GILMOR

The real-time automatic processing and external transmission of meteorological and meteorological-support data will be performed by the NDHS. A USWB DAF-assigned meteorological team at the GILMOR DAF station will prepare any manual nephanalyses required and select any rapid-processed kinescope pictures to be transmitted in real time.

The meteorological team has the basic responsibilities of (1) quality-control monitoring of the receipt and transmission of satellite meteorological and meteorological-support data, (2) performing emergency operations during the periods of wideband link communication failure,

and (3) preparing documents for the archives. Certain functions must be performed regardless of the normal-versus-emergency status of the operation. Included in this category are the following tasks:

- Examination of the rapid-processed kinescope photographs and the HRIR film for unusual meteorologically significant developments, identification and rough location of the phenomena, and "flash" notification to NWSC DAPAF.

- Examination of the same filmstrips for information regarding the operation of the meteorological sensors and the overall satellite ground equipment system and notification of NDHS engineering personnel and/or NTCC of significant observations.

- Preparation of documentation of all factors affecting the accuracy and success of the DAPAF archiving operation.

4.1 EMERGENCY OPERATIONS

During emergency operations, the USWB DAF meteorological team will accomplish the following special tasks:

- Prepare manual nephanalyses of AVCS data for transmission to NTCC/NWSC via the SCAMA 3-kc facsimile circuit. The nephanalyses will be similar to those produced for the TIROS operation.

- Prepare manual analyses of HRIR data for transmission to NTCC/NWSC via the 3-kc facsimile circuit.

- Prepare selected gridded photos of AVCS and HRIR information for transmission to NTCC/NWSC.

- Inform NWSC by voice or teletype circuits of any unusual circumstances affecting the receipt, processing, or transmission of meteorological and meteorological-support data.

4.2 NORMAL OPERATIONS

In the normal mode of operations the USWB DAF meteorological team will accomplish the following tasks:

- Preparation of manual nephanalyses of HRIR and AVCS data for training purposes. Analysis and transmission schedules will simulate emergency operations.

- Preparation of special or local area analyses in support of Alaskan area weather services and as required by NWSC.

- Performance of inhouse research to improve and increase the operational utility of the manual nephanalyses and AVCS/HRIR data.

- Monitoring of the reception of the APT data and assisting Eielson AFB, Weather Bureau Air Station (WBAS) Fairbanks, and WBAS Anchorage in the interpretation of this information.

4.3 METEOROLOGICAL AND SUPPORT DATA TRANSMISSION

The meteorological and meteorological-support data transmitted from the DAF station will consist of HRIR, HRIR time code, AVCS, AVCS time code, attitude, selected-telemetry-parameter, and supplementary data and voice information. The method of transmission of these data is dependent upon the operational mode in effect at the station. The various modes under which data are transmitted include: normal, computer failure, wideband link failure, and others.

4.3.1 NORMAL OPERATION

During normal operations, acquisition of meteorological and support data will be from a single-orbit transit. Two CDC 924 computers and eight tape decks will normally be used to process data by means of a parallel operation in the DAF operational data-handling sequence. The use of only one CDC 924 computer processing the data sequentially will result in a 15-minute delay in the completion of AVCS gridding and transmission of the results to NTCC/NWSC. An 8-minute delay will occur in the processing and transmission of the HRIR data.

Grid-point generation and superposition of the latitude and longitude information on the AVCS triplets and HRIR data will occur synchronously with the transmission of the basic data over the wideband communications system to NTCC/NWSC.

4.3.1.1 Data and Format

Both AVCS and HRIR subsystems produce pictorial representation of cloud cover. The AVCS and HRIR data are received at the DAF station from the spacecraft's 1700-Mc transmitter in the form of FM signals. Telemetry data are received at the DAF station from the spacecraft's 136.5-Mc transmitter. The meteorological and support data are recorded on the Mincom tape equipment at the rate of 60 ips. The AVCS data are played back at an 8:1 slow-down rate and HRIR data at spacecraft

transmission speed, and then are transmitted over the wideband communication system to NTCC/NWSC. Telemetry data, HRIR time, and AVCS real time are also transmitted at 60 ips.

4.3.1.2 Microwave Channelization and Schedules

The signals from the DAF station to NTCC/NWSC will be transmitted in two 48-kc bands via microwave through the AT&T X-108 equipment and by lead lines (see Part IV, 1.14.2 for a description of the X-108). The transmission of the data is arranged in three modes. Digital, AM, and FM signal schemes are used to transmit the data from the DAF station to NTCC/NWSC. NTCC will schedule mode switching and priority of data transmission.

4.3.2 OPERATION DURING COMPUTER FAILURE

Normal operation assumes a two-computer status at the DAF stations; therefore, computer failure will infer a one-CDC 924 computer operation. The use of one computer will result in a delay of 15 minutes from the nominal case in the transmission of the basic data to NTCC/NWSC.

4.3.3 OPERATION DURING MICROWAVE FAILURE

During microwave failure, no AVCS analog or HRIR signals are transmitted to NTCC/NWSC. Manual nephanalyses will be prepared by the USWB DAF meteorological team on a real-time routine basis. These analyses will be transmitted by the 3-kc SCAMA facsimile line. Selected gridded kinescope-produced photographs will also be transmitted.

4.3.4 OPERATION UNDER OTHER CONDITIONS

4.3.4.1 Failed A-Stored Playback

If there is a failure in the A-stored playback system, attitude data will not be available, the time versus computations will be performed on the basis of zero attitude error. HRIR gridding will begin a few minutes earlier than in the normal two-computer case. There is no change in handling of the AVCS data.

4.3.4.2 Simultaneous Failure of CDC 924 Computers

The loss of the two CDC 924 computers simultaneously will preclude any PCM processing and gridding of HRIR and AVCS data. Therefore, no PCM data will be available in real time and the meteorological data will be transmitted ungridded and earlier than in the nominal case.

4.3.4.3 Double-Orbit Acquisition

In double-orbit acquisition twice as much data are received, requiring double the normal times for AVCS transmission, playback, and display.

No change is required in the processing of the data from the most recent orbit. For the earlier or stored orbit, grids will be computed at the DAF station on the basis of picture time alone since no PCM data will be available for attitude correction. Voice communication will be used as necessary to explain or amplify pertinent meteorological features of the blind orbit.

5. REMOTE OPERATION OF GILMOR AND GSFC NDHS

In conjunction with the present planned mode of operation at GILMOR incorporating the GILMOR DAF and NDHS equipment, a second or remote mode of operation is also to be carried out during the life of the Nimbus A spacecraft.

Provisions have been made for a Mode III position in the X-108 data terminal which will provide the following: (1) the capability of transmitting received PCM telemetry in real time from GILMOR to the GSFC NDHS PCM station for processing, (2) the sending of commands from the GSFC NDHS command station to the GILMOR DAF command transmitters for transmission to the spacecraft, and (3) the sending of command verification from GILMOR to the GSFC NDHS command station. Operation of the AVCS/HRIR in the remote mode will remain the same. The AVCS/HRIR data will be recorded on magnetic tape and retransmitted in slow time to GSFC for processing. No processing of AVCS or HRIR will be done at GILMOR during this phase. The PCM and command operation would be carried out similar to the planned GSFC ROSMAN operation.

6. TRANSMITTING SYSTEM CALCULATIONS

6.1 136.5-Mc POWER CALCULATIONS

Carrier Frequency		135.5 Mc
Modulation Type	Spacecraft clock	PDM/AM/AM real time
	Telemeter A	PCM (NRZ-C)/AM stored and real time*
	Telemeter B	PCM (NRZ-M)/PSK/AM real time
Modulation index (m)		.8
Antenna polarization		Right-hand circular

*In real time, telemeter A and spacecraft clock signals are mixed.

Antenna Type	Quadraloop
Effective antenna gain	-4 db
Carrier power (unmodulated)	250 mw (24.0 dbm)
Transmitter power $P_T = P_c\left(1+\frac{m^2}{2}\right)$	330 mw (25.2 dbm)

6.1.1 RECEIVED CARRIER POWER CALCULATIONS INTERFEROMETER

<u>Worst Case</u>

Carrier power (unmodulated)	24.0 dbm
Transmitting antenna effective gain	-4.0 db
Null maximum due to spacecraft orientation (assuming earth orientation)	-6.0 db
Polarization loss	-3.0 db
Path loss at maximum slant range (713 miles) (assume no tracking below 40° zenith angle)	
Free-space transmission loss (L_{fs}) (-36.6-20 log f-20 log R)	-136.3 db
f in megacycles and R in statute miles	
Absorption of signal through the total atmosphere at 40° zenith angle	0.0 db
Receiving antenna effective gain (40° zenith angle on fine antenna)	13.3 db
Passive element losses receiving system	-1.5 db
System operating margin	-6.0 db
Received carrier power at maximum slant range (P_c)	$\boxed{-119.5 \text{ db}}$

<u>Best Case</u>

Carrier power (unmodulated)	24.0 dbm
Path loss at minimum slant range 570 mile (Satellite at perigee and zenith angle 0°)	
Free-space loss (L_{fs})	-134.3 db
Absorption of signal through the total atmosphere at 0° zenith angle	0.0 db
Receiving antenna effective gain (0° zenith angle on fine antenna)	16.3 db
Passive element losses, receiving system	-1.5 db
Transmitting antenna effective gain	-4.0 db
Polarization loss	-3.0 db
System operating margin	-6.0 db
Received carrier power at minimum slant range (P_c)	$\boxed{-108.2 \text{ dbm}}$

Interferometer Noise Power Calculations

Average antenna effective noise temperature (T_A) 1400°K

Receiver noise figure (NF) 2.5

Receiver effective noise temperature (T_e) 440°K

T_e = (NF = 1) To To = ambient temperature

Passive element losses (L_p) 1.4

Effective noise temperature of passive elements (T_p) 85°K

$T_p = T_t (1-1/L_p)$ T_t = average temperature of passive elements

System noise temperature 1525°K

$T_s = T_A/L_p + T_p + T_e$

Receiver input noise power (P_n) -126.8 dbm

P_n (dbm) = (10 log K + 10 log T_s + 10 log B_n + 30)

= -198.6 + 10 log To + 10 log B_n

K = Boltzmann's constant = 1.38×10^{-23} Joules/°K

B_n = noise bandwidth in cps (IF bandwidth is a good approximation)

Interferometer Predetection Carrier-to-Noise Power Ratio

CNR = P_c (dbm) = P_n (dbm)

CNR (maximum slant range) = -119.5 - (-126.8) = + 7.3 db

CNR (minimum slant range) = -108.2 - (-126.8) = + 18.6 db

Interferometer Postdetection Signal-to-Noise Power Ratio*

SNR (maximum slant range) - 30.9 db

SNR (minimum slant range) - 48.6 db

for CNR 10 dbm SNR - 10 log B/b + CNR

CNR 10 dbm SNR - 10 log B/B + 2 CNR - 10 log (2+4 antilog CNR/10)

B = predetection bandwidth

b = postdetection bandwidth

6.1.2 136-Mc PCM TELEMETRY POWER CALCULATIONS

Worst Case

Transmitter power (modulated) P_t	25.2 dbm
Receiving antenna gain	26.0 db
Transmitting antenna effective gain	-4.0 db
Null maximum due to spacecraft orientation (assuming earth orientation)	-6.0 db
Path loss at maximum slant range 1625 statute miles (assuming elevation of 10°)	
Free-space transmission loss (L_{fs}) (-36.6-20 log f-20 log R)	-143.3 db
f in megacycles and R in statute miles	

*A SNR of 30 db or better is necessary for digital tracking data.

Polarization loss	-3.0 db
Absorption of signal through the total atmosphere	0.0 db
Passive element losses receiving system	0.0 db
System operating margin	-6.0 db
Received modulated carrier power total P_c	$\boxed{-111.0 \text{ dbm}}$

Best Case

Transmitter power (modulated) P_t	25.2 dbm
Receiving antenna gain	26.0 db
Transmitting antenna effective gain	-4.0 db
Null maximum due to spacecraft orientation (assuming earth orientation)	0.0 db
Path loss at minimum slant range 570 statute miles (assuming elevation of 90°)	
Free space loss (L_{fs}) (-36.6-20 log f-20 log R)	-134.4 db
f in megacycles and R in statute miles	
Absorption of signal through the total atmosphere	0.0 db
Passive element losses, receiving system	0.0 db
System operating margin	-6.0 db
Received modulated carrier power total P_c	$\boxed{-93.2 \text{ db}}$

136-Mc Telemetry Noise Power Caculations

Average antenna effective noise temperature (T_A)	1400°K
Receiver noise figure 2.25	
Receiver effective noise temperature (T_e)	361°K
$E_e = (NF-1)$ To To = ambient temperature	
Passive element losses (L_p) 1	
Effective noise temperature of passive elements T_p	0.0
$T_p - T_t (1-1/L_p)$	
System noise temperature (T_s)	1761°K
$T_c = T_A/L_p + T_p + T_e$	
Receiver input noise power (P_n)	$\boxed{-116.2 \text{ dbm}}$

P_n (dbm) = (10 log K + 10 log T_s + 10 log B_n + 30)

= -198.6 + 10 log T_s + 10 log B_n

K = Boltzmann's constant = 1.38×10^{-23} Joules/°K

B_n = noise bandwidth in cps (IF bandwidth is a good approximation)

Telemetry Carrier-to-Noise Power Ratio (CNR)

CNR = P_c (dbm) - P_n (dbm)

CNR (maximum slant range) = -111.1 - (-116.2) = + 5.1 db

CNR (minimum slant range) = - 93.2 - (-116.2) = + 23.0 db

Telemetry Signal-to-Noise Ratio (SNR)

SNR = 10 log m^2 + CNR	
*SNR (maximum slant range)	+3.2 db
SNR (minimum slant range)	+21.1 db

6.2 1707-Mc TELEMETRY POWER CALCULATIONS

Modulation type	FM
Maximum deviation of RF carrier	Approximately 1.7 Mc
Modulation index of RF carrier	Average 1
Antenna type	Spiral conic
Polarization	Right-hand circular
Transmitter power	3.2 watts (35 dbm)

Received Carrier Power Calculations

Worst Case

Transmitter power	35 dbm
Path loss at maximum slant range 1625 statute miles (antenna elevation 10°)	
Free space transmission loss (L_{fs}) (-36.6-20 log f-20 log R)	-165.4 db
f in megacycles and R in statute miles	
Ground station antenna gain	47 db
Gain spacecraft antenna	0 db
Nulls maximum due to spacecraft orientation	0 db
Passive element losses receiving system	0 db
System operating margin	-6.0 db
Total received carrier power (P_c)	$\boxed{\text{-89.4 dbm}}$

Best Case

Only change is in the path loss.	
Antenna elevation 90° slant range 570 statute miles	
Free-space transmission loss (L_{fs}) (-36.6-20 log-20 log R)	-156.3 db
f in megacycles and R in statute miles	
Total received carrier power (P_c)	$\boxed{\text{-80.3 dbm}}$

*The SNR may be improved as much as 3 db in the worst case because diversity combining is used at the 85-foot dish sites. At least a 14-db SNR will be required by NDHS.

Noise Power Calculations

Average antenna effective noise T_a	60°K
Receiver noise 1.6	
Receiver effective temperature T_e = (NF-1) To	174°K
Passive element for receiver system $L_p = 1$	
Effective noise temperature of passive elements $T_p = T_t (1-1/L_p)$	0°K
System noise temperature $T_s = T_A/L_p + T_p + T_e$	234°K
Receiver input noise power (P_n)	$\boxed{-110.1 \text{ dbm}}$

P_n (dbm) = 10 log K + 10 log T_s + 10 log B_n + 30

= -198.6 + 10 log T_s + 10 log B_n

K = Boltzmann's constant = 1.38×10^{-23} Joules/°K

B_n = noise bandwidth in cps (IF bandwidth is a good approximation)

Carrier-to-Noise Power Ratio (CNR)

CNR = P_c (dbm) - P_n (dbm)

CNR (maximum slant range) = -89.4 - (-110.1) = + 20.7 db

CNR (minimum slant range) = -80.3 - (-110.1) = + 29.8 db

Empirical data indicate that a CNR of 15 db is the minimum required for acceptable picture quality. There will be no signal-to-noise ratio improvement through demodulation because a low average modulation index is used.

6.3 COMMAND POWER CALCULATION

Spacecraft atenna type	mono-pole
Spacecraft antenna polarization	linear
Ground command antenna polarization	circular
Command transmitter power	2.5 kw (64 dbm)
Command antenna gain	12.0 db
Command frequency (nominal)	120 Mc
Spacecraft antenna gain	-10 db
Polarization loss	-3 db
Path loss at maximum slant range 1625 statute miles (antenna elevation 10°)	
Free-space transmission loss (L_{fs}) (-36.6-20 log f-20 log R)	-142.7 db
f in megacycles and R in statute miles	
System operating margin	-6 db
Total received unmodulated carrier power	$\boxed{-88.7 \text{ dbm}}$
Receiver threshold (unmodulated carrier power)	$\boxed{-105 \text{ dbm}}$

The operating margin is therefore 16.3 db

PART VI

APT STATION OPERATION

This part outlines the APT ground station operation, the Nimbus APT evaluation plan, and describes the APT ground station equipment. The Nimbus project APT Coordinator, A. Cunningham, working in the NTCC, will be responsible for coordination of all Nimbus project APT requirements and for all APT data received from the APT stations.

The APT stations acquire cloud picture data that are reproduced as photographic images by a facsimile recorder. APT stations have been built by the Weather Bureau, the U.S. Navy, U.S. Army, and the U.S.A.F. Air Weather Service. Under the international meteorological program, APT stations have been built by many foreign countries. The Nimbus APT Coordinator is responsible for participation of all stations in the Nimbus APT program. In conjunction with the NTCC Manager, the APT Coordinator will put requests for APT programming into the Nimbus program priority list and inform new or potential stations when they can receive APT transmissions.

1. STATION OPERATION

In order to acquire the spacecraft, and to locate, geographically orient, and grid the pictures transmitted from the spacecraft, each APT station will be furnished three types of materials and information:

- A kit of working material which will include tables, regional maps, overlays, and using instructions
- The Nimbus APT Daily Alert and Ephemeris Prediction (NADA) messages, which will include the minimum predictive data required by the ground station to track the spacecraft and to locate, orient, and grid the facsimile pictures. The daily messages will reflect the latest orbital data and will be teletyped to the APT stations daily by the World Meteorological Organization (WMO) telecommunication network, in accordance with the WMO manual on codes. The format of the daily teletype message is shown in Table VI-1; a sample message is given in Table VI-2.
- The Nimbus weekly messages, which will contain NADA's for 14 days, for planning purposes and for maintaining operations if

Table VI-1

Format of Daily Alert and Ephemeris Prediction Message

TBUS 2 KWBC ____________ Z

APT PREDICT

MMYYSS

PART I

$ON_rN_rN_rN_r$ $OY_rY_rG_rG_r$ $Og_rg_rs_rs_r$ $Q_rL_oL_ol_ol_o$ Tggss $LL_oL_ol_ol_o$

$N_4N_4N_4N_4G_4$ $G_4g_4g_4s_4s_4$ $Q_4L_oL_ol_ol_o$

$N_8N_8N_8N_8G_8$ $G_8g_8g_8s_8s_8$ $Q_8L_oL_ol_ol_o$

$N_{12}N_{12}N_{12}N_{12}G_{12}$ $G_{12}g_{12}g_{12}s_{12}s_{12}$ $Q_{12}L_oL_ol_ol_o$

PART II

$02Z_{02}Z_{02}Q_{02}$ $L_aL_aL_aL_oL_oL_o$ $04Z_{04}Z_{04}Q_{04}$ $L_aL_aL_aL_oL_oL_o$

$06Z_{06}Z_{06}Q_{06}$ $L_aL_aL_aL_oL_oL_o$ $08Z_{08}Z_{08}Q_{08}$ $L_aL_aL_aL_oL_oL_o$

$10Z_{10}Z_{10}Q_{10}$ $L_aL_aL_aL_oL_oL_o$ ---etc.

PART III

$02Z_{02}Z_{02}Q_{02}$ $L_aL_aL_aL_oL_oL_o$ $04Z_{04}Z_{04}Q_{04}$ $L_aL_aL_aL_oL_oL_o$

$06Z_{06}Z_{06}Q_{06}$ $L_aL_aL_aL_oL_oL_o$ $08Z_{08}Z_{08}Q_{08}$ $L_aL_aL_aL_oL_oL_o$

$10Z_{10}Z_{10}Q_{10}$ $L_aL_aL_aL_oL_oL_o$ ---etc.

PART IV

Table VI-1 (Continued)

Format of Daily Alert and Ephemeris Prediction Message

EXPLANATION OF CODE SYMBOLS

TBUS 2 - Nimbus APT Bulletin originating in the United States

KWBC - Traffic entered at Washington, D.C.

APT PREDICT - Identifies message content.

MMYYSS - Message serial number
- MM - month of year
- YY - day of month
- SS - number of Nimbus spacecraft to which predict applies.

PART I - Equator crossing predicts follow.

$ON_rN_rN_rN_r$ $OY_rY_rG_rG_r$ $Og_rg_rs_rs_r$

O - Indicator, reference orbit equator crossing information follows. (NOTE: Information in Parts II and III applies directly to this reference orbit.)

$N_rN_rN_rN_r$ - Number of reference orbit.

$Y_rY_rG_rG_rg_rg_rs_rs_r$ - Day (YY), hour (GG), minute (gg), and second (ss)-GMT - on which satellite crosses the equator northbound on the reference orbit $N_rN_rN_rN_r$.

$Q_rL_oL_ol_ol_o$ - Octant and longitude in degrees and hundredths at which satellite crosses the equator northbound on reference orbit $N_rN_rN_rN_r$. (Octant at equator will be that into which the satellite is moving.)

T - Indicator, nodal period follows.

ggss - Nodal period, minutes and seconds between consecutive equator crossings. (Hundreds group will not be included: ex. 100 minutes 13 seconds will be coded as 0013.)

Table VI-1 (Continued)

Format of Daily Alert and Ephemeris Prediction Message

L	- Indicator, nodal longitude increment follows:
$L_oL_ol_ol_o$	- Degrees and hundredths of longitude degrees between consecutive equator crossings.
$N_4N_4N_4N_4$	- Number of the fourth orbit following the reference orbit.
$G_4G_4g_4g_4s_4s_4$	- Hour (GG), minute (gg), and second (ss), at which satellite crosses the equator northbound on orbit $N_4N_4N_4N_4$.
$Q_4L_oL_ol_ol_o$	- Octant and longitude in degrees and hundredths at which satellite crosses equator northbound on orbit $N_4N_4N_4N_4$.
$N_8N_8N_8N_8$ $N_{12}N_{12}N_{12}N_{12}$	- 8th and 12th orbits following reference orbit.
PART II	- Satellite altitude and subpoint coordinates at 2 minute intervals—after time of equator crossing follows.
$02Z_{02}Z_{02}Q_{02}$	
02	- Information pertinent to 2 minutes after equator crossing follows.
$Z_{02}Z_{02}$	- Satellite altitude in tens of kilometers. At 2 minutes after equator crossing.
Q_{02}	- Octant of globe at 2 minutes after equator crossing.
$L_aL_aL_aL_oL_oL_o$	
$L_aL_aL_a$	- Latitude of satellite subpoint in degrees and tenths of degrees at 2 minutes after equator crossing.

Table VI-1 (Continued)

Format of Daily Alert and Ephemeris Prediction Message

$L_oL_oL_o$	- Longitude of satellite subpoint in degrees and tenths of degrees at minute 2 after equator crossing.

(This information is repeated at 2-minute intervals of the sunlit portion of the orbit of the equator.)

PART III	- Satellite altitude and subpoint coordinates at 2 minute intervals prior to time of equator crossing follows.
$02Z_{02}Z_{02}Q_{02}$	
02	- Information pertinent to minute 2 before equator crossing follows.
$Z_{02}Z_{02}$	- Satellite altitude in tens of kilometers at 2 minutes before equator crossing.
Q_{02}	- Octant of globe at 2 minutes before equator crossing.
$L_aL_aL_aL_oL_oL_o$	
$L_aL_aL_a$	- Latitude of satellite subpoint in degrees and tenths of degrees at minute 2 before equator crossing.
$L_oL_oL_o$	- Longitude of satellite subpoint in degrees and tenths of degrees at minute 2 before equator crossing.

(This information is repeated at 2-minute intervals over the sunlit portion of the orbit south of the equator.)

PART IV	- Remarks

Table VI-2

Sample of Daily Alert and Ephemeris Prediction Message

TBUS 2 KWBC Z

APT PREDICT

122301

PART I

01421 02714 00000 07500 T0135 L2530
14252 04620 17620 14290 33240
28260 14331 01900 01760

PART II

02840 070766 04840 140783 06840
210800 08840 280819 10830 349839 12830
418862 14830 487890 16831 556924 18831
624962 20831 689044 22821 750168 24821
801422 26822 806752 28832 771421

PART III

02845 070734 04845 140717 06845 210700
08845 280681 10845 349661 12845 418638
14845 487610 16855 556576 18855 624538
20855 689456 22855 750332 24855 801078
26858 806348 28858 771679

normal teletype communications fail. The weekly messages will be prepared 10 days in advance and will be mailed to the APT stations from GSFC each week.

Detailed instructions on spacecraft acquisition and specific picture gridding procedures, along with the kit of working materials, have already been provided to each APT station by the National Weather Satellite Center (NWSC).

2. NIMBUS APT EVALUATION PLAN

Effectiveness of the Nimbus APT operations will be evaluated in two phases. Phase I will be accomplished by the key stations listed below, and will provide an engineering checkout of the system. Phase II will consist of an operational evaluation of the entire system by all of the APT stations that are programmed for data.

The key APT stations and their managers are as follows:

RCAHNJ-RCA-AED - M. Harper, Station Manager, 609-448-3400 Ext. 2328

WALACQ - Wallops Island TIROS CDA station, C. Lundstedt, Station Manager, 824-3411, Ext. 208

GILMOR - Nimbus DAF station, L. Covington, Station Manager. 907-452-1466

ULASKA - TIROS CDA station, G. Newell, Station Manager, 907-452-1155

SFCAPT - GSFC - W. Risley, Station Manager, 301-982-5345

WEABUR - U.S. Weather Bureau, NWSC - A. Schwalb, Station Manager, 301-735-2000, Ext. 7148

AFCRLA - Air Force Cambridge Research Center - T. Keegan, Station Manager, 617-274-6100 Ext.2981

PMRWEA - PMR TIROS CDA station, R. McIntyre, Station Manager, 805-448-3511, Ext. 7137

The APT ground stations are listed in Table VI-3; station identifications are listed alphabetically in Table VI-4. The ULASKA station will receive APT data both as a key station and during routine operations.

Table VI-3

APT Station Locations

Air Force Stations	Latitude	Longitude	Elevation
Hanscom Field, Bedford, Mass.	42°28'N	71°71'W	132 ft.
Vandenberg AFB, Calif.	34°43'N	120°33'W	369 ft.
Westover AFB, Mass.	42°12'N	72°32'W	262 ft.
Offutt AFB, Neb.	41°7'N	95°54'W	1023 ft.
Colorado Springs AFB, Colo.	38°49'N	104°42'W	6170 ft.
Fuchu AFB, Japan	34°21'N	133°7'E	-
High Wycombe, England	51°23'N	0°28'W	-
Ramstein AB, Germany	49°16'N	7°20'E	-
Kadena, Okinawa	26°21'N	127°45'E	163 ft.
Elmendorf, Alaska	61°15'N	149°48'W	192 ft.
Langley AFB, Va.	37°5'N	76°21'W	12 ft.
Kunia Camp, Hawaii	21°27'N	158°5'W	-
Keesler AFB, Miss.	30°24'N	88°55'W	36 ft.
Kindley AFB, Bermuda	32°22'N	64°40'W	17 ft.
Lajes Field, Azores	38°45'N	27°5'W	177 ft.
Clark AB, Philippines	15°10'N	120°34'E	643 ft.
Adana, Turkey	36°59'N	35°18'E	69 ft.
Navy Stations			
McMurdo Sound, Antarctica	77°31'S	166°22'E	-
Christchurch, New Zealand	43°32'S	172°37'E	25 ft.
Agana, Guam	13°29'N	144°48'E	269 ft.
San Diego, Calif.	32°42'N	117°12'W	-
U.S.S. Saratoga			
Rota, Spain			
NASA Stations			
GSFC, Greenbelt, Md.	39°N	77°W	-
DAF Stations, Gilmore Creek, Alaska	64°49'N	147°52'W	454 ft.
CDA Station, Wallops Station, Va.	37°56'N	75°28'W	-
CDA Station, Pt. Mugu, Calif.	34°7'N	119°7'W	-
CDA Station, RCA, Princeton, N.J.	40°7'N	75°W	-

APT Station Locations (continued)

Weather Bureau Stations	Latitude	Longitude	Elevation
Honolulu, Hawaii	21°20'N	157°55'W	15 ft.
Anchorage, Alaska	61°10'N	149°59'W	132 ft.
Chicago, Ill.	41°8'N	87°8'W	-
Seattle, Wash.	47°26'N	122°20'W	450 ft.
San Francisco, Calif.	37°37'N	122°23'W	18 ft.
Kansas City, Mo.	39°7'N	94°35'W	750 ft.
San Juan, Puerto Rico	18°28'N	66°7'W	82 ft.
Miami, Fla.	25°49'N	80°17'W	12 ft.
New Orleans, La.	30°0'N	90°15'W	30 ft.
Kennedy International Airport, N.Y.	40°39'N	73°47'W	16 ft.
Boston, Mass.	42°22'N	71°1'W	29 ft.
Washington, D.C. (Suitland, Md.)	38°51'N	77°2'W	65 ft.
Army Station			
Ft. Monmouth, N.J.	40°N	75°5'W	
Stations in Participating Nations			
Lannion, France	48°8'N	03°00'W	
Malvern (Bracknell), England	51°25'N	00°45'W	
IIOE, Colaba Observatory, Bombay, India	19°07'N	72°50'E	
Melbourne, Australia			
Hong Kong	22°19'N	114°12'E	
Copenhagen, Denmark	55°7'N	13°6'E	
Montreal, Canada	45°28'N	73°45'W	
Ottawa, Canada	45°19'N	75°40'W	
Offenbach Am Main, Germany	50°06'N	08°45'E	
Bandung/Husein, Indonesia	6°54'S	107°35'E	

Table VI-4

APT Station Identifications		
ADANA	-	Adana, Turkey
AGANAG	-	Agana, Guam
ANCHOR	-	Anchorage, Alaska
ARGENT	-	Argentia, Newfoundland
BANDNG	-	Bandung/Husein, Indonesia
BOSTON	-	Boston, Mass.
COLABA	-	Colaba Observatory, India
CHICAG	-	Chicago, Ill.
CHRIST	-	Christchurch, New Zealand
CLARK	-	Clark AB, Phillipines
COLORA	-	Peterson AFB, Colorado Springs, Colo.
COPNHG	-	Copenhagen, Denmark
ELMEND	-	Elmendorf, Alaska
FUCHU	-	Fuchu AFB, Japan
GILMOR	-	Gilmore Creek, Alaska, DAF
HANSCO	-	Hanscom Field, Bedford, Mass.
HIGHWY	-	High Wycombe, England
HONGKG	-	Hong Kong
HONOLU	-	Honlulu, Hawaii
IDLEWI	-	Kennedy International Airport, N. Y.
KADENA	-	Kadena, Okinawa
KANSAS	-	Kansas City, Mo.
KINDLE	-	Kindley AFB, Bermuda
KUNIA	-	Kunia Camp, Hawaii
LAJES	-	Lajes Field, Azores
LANGLE	-	Langley AFB, Va.
LANION	-	Lannion, France
MALVRN	-	Bracknell, England
MCMURD	-	McMurdo Sound, Antarctica
MELBOR	-	Melbourne, Australia
MIAMIF	-	Miami, Fla.
MONTRL	-	Montreal, Canada
NEWORL	-	New Orleans, La.
OFFUTT	-	Offutt AFB, Neb.
OFNBCH	-	Offenbach Am Main, Germany
OTTAWA	-	Ottawa, Canada
PMRWEA	-	CDA Station, Pt. Mugu, Calif.
PTMUGU	-	Pt. Mugu, Calif.
RAMSTE	-	Ramstein AB, Germany

APT Station Identifications (continued)		
RCAHNJ	-	CDA Station, RCA, Princeton, N. J.
RDLAWA	-	Ft. Monmouth, N. J.
SANDGO	-	San Diego, Calif.
SANJUA	-	San Juan, Puerto Rico
SEATTL	-	Seattle, Wash.
SFCAPT	-	Goddard Space Flight Center, Greenbelt, Md.
ULASKA	-	Gilmore Creek, Alaska, CDA Station
VANDEN	-	Vandenburg AFB, Calif.
WALLAQ	-	CDA Station, Wallops Station, Va.
WEABUR	-	National Weather Satellite Center, Suitland, Md.
WESTOV	-	Westover AFB, Mass.

The Nimbus APT station, at GILMOR, receives APT data during the first three days of operation and then as directed by NTCC.

The mailing list for APT stations is:

A. U.S. Weather Bureau

1. Meteorologist In Charge
   Weather Bureau Airport Station
   East Boston 28, Massachusetts

2. Meteorologist In Charge
   Weather Bureau Airport Station
   Hanger 11
   Kennedy International Airport
   Jamaica 30, Long Island, New York

3. Chief District Meteorologist
   District Meteorological Office
   Aviation Building
   3240 N.W. 27 Avenue
   Miami 42, Florida

4. Meteorologist In Charge
   Weather Bureau Office
   701 Loyola Avenue
   New Orleans 12, Louisiana

5. Chief Airport Meteorologist
   Weather Bureau Airport Station
   Midway Airport
   6200 South Cicero Avenue
   Chicago 38, Illinois

6. Meteorologist In Charge
   Weather Bureau Forecast Center
   5730 Woodlawn Avenue
   Chicago 37, Illinois

7. Chief District Meteorologist
   District Meteorological Office
   911 Federal Office Building
   Kansas City, Missouri

8. Meteorologist In Charge
Weather Bureau Airport Station
Municipal Airport
Kansas City, Missouri

9. Meteorologist In Charge
Weather Bureau Airport Station
San Francisco International Airport
Box 8247
San Francisco 28, California

10. Meteorologist In Charge
Weather Bureau Airport Station
Seattle-Tacoma Airport
Seattle 88, Washington

11. Meteorologist In Charge
Weather Bureau Airport Station
Box 6047
Airport Annex Branch
Anchorage, Alaska

12. Meteorologist In Charge
Weather Bureau Airport Station
Honolulu International Airport
Post Office Box 9428
Honolulu, Hawaii

13. Meteorologist In Charge
U.S. Weather Bureau Airport Station
Isla Verde International Airport
San Juan, Puerto Rico

14. U.S. Weather Bureau
National Weather Satellite Center
8-3.21
Washington, D.C. 20235

B. International Program

1. Dr. C. S. Ramage
Int. Indian Ocean Exp.
Met. Program
Calaba Observatory
Bombay (5) India

U.S. Contacts
Dr. White
National Science Foundation
183-6442

2. Centre D'etudes Meteorologigues Spatiale
Centre De-Recherches De Lannion
Lannion (Cotes DuNord)
France
Attention: M' Louis Le. Ninivin

3. Satellite Data Laboratory
Meteorology Branch
Department of Transport
Room 253, Bldg. M-50
National Research Council
Ottawa, Ontario, Canada

4. Dr. N. E. Rider
Meteorological Office
London Road
Bracknell, Berkshire, England

5. Dr. I. E. M. Watts
Director, Royal Observatory
Nathan Road
Kowloon, Hong Kong

6. H. Fielstette
Deutscher Wetterdienst
Zentralamt Abteilung FMD
Frankfurter Strasse 135
Offenbach Am Main
Federal Republic of Germany

7. Dr. A. Lundbak
Director, Danish Met Institute
Copenhagen, Denmark

8. Mr. W. J. Gibbs
   Director of Meteorology
   Department of Interior
   Box 1289, KGPO
   Melbourne C1, Australia

9. Director
   Weapons Research Establishment
   Salisbury, South Australia

10. Dr. Ing Iskandar Alisjahbana
    Radio and Microwave Laboratory
    I.K.B., Dj. Ganefa 10
    Bandung, Indonesia

11. Dr. Fernando de Mendonca
    Comissao Nacional de Atividades Espaciais
    S. Jose dos Campos, S.P. - Brazil

12. Mr. Francois P. M. Gandchamp
    Radio-Suisse
    Case Postale
    Bern 25, Switzerland

13. Mr. M. A. Thomae
    Jefe De La Seccion Electronica
    Universidad Nacional De Treueman
    San Miguel de Treueman
    Republic of Argentina, S. A.

C. U.S. Navy

1. Commanding Officer
   Fleet Weather Central
   Guam, Mariannas Islands

2. Commanding Officer
   Navy Electronics Laboratory
   Code 3240
   San Diego, California

3. Commander
Naval Support Forces Antarctica
Meteorological Officer
Christchurch, New Zealand
(Note: Mail 2 books)

4. Commanding Officer
U.S.S. Saratoga (CVA-60)
Aerology Department
Fleet Post Office, New York

D. U.S. Army

1. Commanding Officer
U.S. Army Electronics R&D Laboratory
Meteorolcgy Division
Fort Monmouth, New Jersey
Attention: Mr. K. Steelman

E. U.S.A.F. Air Weather Service

1. Mr. T. Keegan
Geophysics Research Directorate - AFCRL
L. G. Hanscom Field
Bedford, Massachusetts

2. Officer In Charge
Detachment #1, 3rd Weather Wing
Offutt Air Force Base, Nebraska

3. Commander
Detachment 1, 4th Weather Wing
Ent Air Force Base, Colorado 80912

4. Officer In Charge
Detachment #2, 2nd Weather Group
Langley Air Force Base, Virginia

5. Officer In Charge
Detachment #9, 8th Weather Squadron
Westover Air Force Base, Massachusetts

6. Officer In Charge
   Detachment #3, 3rd Weather Wing
   Vandenburg Air Force Base, California

7. Officer In Charge
   Detachment #13, 11th Weather Squadron
   APO 942, Seattle, Washington (Elmendorf AFB, Alaska)

8. Officer In Charge
   Detachment #3, 1st Weather Wing
   APO 915, San Francisco, California (Wheeler AFB, Hawaii)

9. Officer In Charge
   Detachment #1, 1st Weather Wing
   APO 925, San Francisco, California (Fuchu Air Sta, Japan)

10. Officer In Charge
    Detachment #5, 1st Weather Wing
    APO 74, San Francisco, California (Clark, Philippines Islands)

11. Officer In Charge
    Detachment #8, 1st Weather Wing
    APO 239, San Francisco, California (Kadena AFB, Okinawa)

12. Officer In Charge
    Detachment #40, 28th Weather Squadron
    APO 241, New York, New York (High Wycombe AFB, England)

13. Officer In Charge
    Detachment #21, 31st Weather Squadron
    APO 12, New York, New York (Ramstein AFB, Germany)

14. Officer In Charge
    Detachment #18, 15th Weather Squadron, 8th Weather Group
    APO 856, New York, New York (Kindley, Bermuda)

15. Officer In Charge
    Detachment #19, 15th Weather Squadron
    APO 406, New York, New York (Lajes, Azores)

16. TUSLOG, Detachment 2
    APO 289, New York, New York (Imcirlik, Turkey)

17. Commander
    Detachment #15, 1st Weather Wing
    APO San Francisco, California (Osan, Korea)

18. Commander
    30th Weather Squadron
    APO 143, San Francisco, California (Tan-Son-Mhut, Viet Nam)

19. Commander
    Detachment #17, 31st Weather Squadron
    APO 253, New York, New York (Evreaux, France)

20. Commander
    Detachment #11, 4th Weather Wing
    Patrick Air Force Base, Florida

F. <u>NASA Stations</u>

1. Mr. W. Hood
   Radio Corporation of America
   Astro-Electronics Division
   Princeton, New Jersey

2. Mr. E. Rosenstock
   Fairchild-Stratos Corporation
   Electronics Systems Division
   Bayshore, Long Island, New York

3. Mr. C. Lundstedt
   TIROS CDA Station Manager
   NASA Wallops Station
   Wallops Island, Virginia

4. Mr. R. McIntyre
   TIROS CDA Station Manager
   Pacific Missile Range
   Point Mugu, California

5. Mr. G. Newell
   TIROS CDA Station Manager
   NASA Data Acquisition Facility
   Mile 13-Steese Highway
   Fairbanks, Alaska

6. General Electric Company
   Valley Forge Space Technology Center
   Spacecraft Dept.
   P. O. Box 8555
   Philadelphia 1, Pa.
   Attention: S. Charp

G. Private Users   Weekly Only

1. Prof. Vernor Suomi
   Department of Meteorology
   University of Wisconsin
   Madison 5, Wisconsin

2. WLAC-TV
   159-4th Avenue N.
   Nashville, Tenn. 37219
   Attention: Ralph L. Hucaby

3. Mr. W. F. Downey
   California Computer Products, Inc.
   305 Muller Avenue
   Anaheim, California

4. M. A. G. Redhead
   RCA Victor Company, Inc.
   1001 Lenoir St.
   Montreal, Canada

2.1 OBJECTIVES

Evaluation of the spacecraft and ground elements of the APT system as to their proper mechanical and electrical performance. Observations required are:

a. Measurements of picture format

b. Detection of start and phasing signals

c. Detection of horizontal sweep frequencies

d. Determination of picture start times, maximum signal levels, ground system receiver quieting, antenna tracking modes and spacecraft positions, and external interference identification if observed.

e. Comparison of low- and high-gain antennas

f. Identification of proper ground system phasing, start, and AGC level.

g. Detection of picture skew.

Determination of the solar elevation angle limits for effective utilization of APT data. Data required are the following:

a. Records of solar elevation angles for all APT pictures

b. APT ground station observations as to effective meteorological analyses from the data

Evaluation of the effectiveness of the prepared APT data user kits and weekly and daily predictive messages. Data required are information on the following:

a. Verification of correct identification and rectification of land features.

b. Picture contrast between clouds, water, and land.

c. Effect of attitude excursions.

Evaluation of the meteorological utility of APT data. Information is required on the following:

a. Identification of cloud patterns associated with conventional synoptic data.

b. Characteristics of cloud features associated with wind patterns, including the jet stream.

c. Differentiation between snow, ice, and cloud features.

d. Cloud types and cloud height determination.

3. PRELAUNCH ACTIVITIES

The key APT ground stations will be included in the prelaunch communications countdown outlined in Part IV. The APT Coordinator will

mail APT pass summary and evaluation reports (Table VI-5) to APT stations two weeks before launch. T&DS Data Systems Division will prepare Nimbus APT Daily and Weekly Ephemeris Prediction messages (Tables VI-1 and VI-2) and give them to the APT Coordinator for transmittal to key APT stations beginning two weeks before launch.

4. POSTLAUNCH ACTIVITIES

Postlaunch activities include engineering checkout and operational evaluation of the APT spaceborne and ground systems.

4.1 PHASE I - ENGINEERING CHECKOUT

The initial engineering checkout of the airborne and ground elements of the APT system will begin with the first turn-on of the system during the spacecraft activation program. This will probably yield pictures to be readout over the eastern area of the United States and Canada by GSFC, NWSC, and others. Programming of APT sequences on later orbits will permit other key stations to receive pictures as the spacecraft passes within range. Phase I will continue until it is verified that APT data can be effectively acquired and processed by the worldwide network of APT stations. Verification will depend on establishment of a satisfactory performance level of APT camera and ground system operation and the completion of orbit calculations which will make possible effective daily predictive messages.

All other APT stations will be furnished actual orbital predictive data for the day after launch (day 1) and updated orbital data on subsequent days after launch during the engineering checkout.

Transmission of the Nimbus APT nominal Daily Alert and Ephemeris Prediction messages to WALACQ, PMRWEA, SFCAPT, RDLAWA, RCAHNJ, WEABUR, GILMOR, and ULASKA for launch day and the three succeeding days will occur two weeks before launch. The APT Coordinator in NTCC will prepare the messages for transmittal via NASCOM.

The Ground Operation Manager, G. Harris, is the responsible person for coordination with NASCOM for assuring that communications requirements for these APT stations are met.

A. Cunningham, the APTS Coordinator, is responsible for the collection of APT data to be evaluated by NTCC or the APT Technical Officer, and for the dissemination of any special information to users. He is

Table VI-5

Nimbus APT Pass Summary and Evaluation Report

This report is to be completed whenever APT pictures are programmed for an APT station.

Station ____________________ orbit ____________ date ____________

1. APT signal acq. __________ Z __________ Strength __________ mv
   APT signal fade __________ Z __________ Strength __________ mv

2. Max. receiver sig., strength __________ mv __________ ° elev.

3. Fax recorder AGC level maintained __________ (yes or no)

4. Tracking mode used __________ (continuous or jog)

5. Interference __________ (yes or no) time _____ Z _____ (min.-sec.)
   identification __________ characteristics __________
   Brief description of interference ____________________

____

6. Pix with video received __________ (yes or no) (If no, comment)

7. Autostart __________ (yes or no) (If no, comment)

8. 300 cps. start __________ (yes or no) (If no, comment)

9. Phasing at 2.8 volts __________ (yes or no) (Scope measurement) (If no, what value?)

10. Tonal change between fax phase and fax start __________ (yes or no)

11. Four cps, horiz. freq. sweep rate ______ (yes or no) (If no, comment) Record on scope a picture of four (4) blanking pulses one trace.

12. 5 sets horizontal fiducials __________ (yes or no) (If no, how many?)

13. Pix size normal __________ (yes or no) (If no, what size?) (Measure video portion only - should be 8" ± 1/4" on Fairchild Fax.)

Table VI-5 (Continued)

Nimbus APT Pass Summary and Evaluation Report

14. Proper phasing frames No. 1____, No. 2____, No. 3______
(yes or no) (If no, comment)

15. Picture start time________Z (for all complete frames)
(Were horizontal lines of fiducial marks adequate determiners of pix start?)

16. Skew noted________ (yes or no) (If yes, comment)

17. Daily msg. easily used________(yes or no) (If no, problems.)

18. Grid error from landmarks________° lat.________° long.

19. Clouds discernible from earth features________(yes or no) (If no, specify observations.)

20. Synoptic interpretations made______(yes or no) (If no, why not?)

21. Weekly msg. used________(yes or no) (If no, comment)

22. Additional comments:

____

Signed: ________________(Shift chief)______________(Station Manager)

also responsible for coordination with GSFC PIO and photographic laboratory.

Responsibilities of the key stations participating in phase I are:

4.1.1 WALLOPS (WALACQ)

a. Complete in detail entire APT pass summary and evaluation report. Teletype the report to NTCC after each pass, for delivery to the APT Coordinator.

b. Real-time evaluation of APT station performance, including camera trigger, PED cycling and timing, sync and sweep stability, grey scale, aspect ratio, and distortion analysis.

c. Evaluate effectiveness of prepared APT station data user kit and the daily and weekly predictive data.

- Spacecraft tracking effectiveness

- Ease of location, orientation, and gridding of the Nimbus APT pictures

d. Evaluate utility of the Nimbus APT pictures for meteorological purposes

e. Provide three photocopies of each picture received to APT Coordinator

4.1.2 RCA-AED (RCAHNJ)

a. Complete in detail items 1 through 17 in the APT pass summary and evaluation report. Teletype the report to NTCC after each pass for delivery to the APT Coordinator.

b. Real-time engineering evaluation of the APT system, including camera trigger, PED cycling and timing, sync and sweep stability, grey scale, aspect ratio, and distortion analysis.

c. Copy APT pictures simultaneously on the Muirhead paper facsimile and photofacsimile recorders. Provide three (3) photo copies to the APT Coordinator of all pictures received on each recording instrument.

d. Summary comparison and analysis of these systems' performance and quality should be included as comments in the APT pass summary and evaluation report.

4.1.3 GSFC (SFCAPT)

a. Complete in detail items 1 through 17 of APT pass summary and evaluation report. Handcarry the report to the APT Coordinator at the end of each day.

b. Record APT pictures simultaneously on the Fairchild and AN/GXC-4 (70-mm rapid-process film) photofacsimile recorders.

c. Playback tape-recorded signals through both the recorder systems for two (2) additional copies of each picture.

d. Playback tape-recorded signals through only the AN/GXC-4 recorder for one additional copy which is to be developed by the GSFC photo laboratory, using regular photographic procedures.

e. The GSFC photo laboratory is to produce three (3) copies of each 70-mm and scanner fax picture for delivery to the APT Coordinator.

f. Compare picture quality of 70-mm rapid-processed film with film developed in standard manner and include in comments in APT pass summary and evaluation report.

4.1.4 USWB-NWSC (WEABUR)

a. Complete entire APT pass summary and evaluation report with detailed analyses of items 18 through 22. Teletype report to NTCC after each pass for delivery to the APT Coordinator.

b. Evaluate APT station performance.

c. Evaluate effectiveness of prepared APT station data users' kit and daily and weekly predictive data.

- Spacecraft tracking effectiveness

- Ease of location, orientation, and gridding of Nimbus APT pictures.

d. Evaluate utility of Nimbus APT pictures for meteorological purposes.

4.1.5 AIR FORCE CAMBRIDGE RESEARCH LABORATORIES (AFCRLA)

a. Complete entire APT pass summary and evaluation report with detailed analyses of items 18 through 22. Teletype the report to NTCC after each pass for delivery to the APT Coordinator.

b. Evaluate APT station performance.

c. Evaluate effectiveness of prepared APT station data users' kit and daily and weekly predictive data.

- Spacecraft tracking effectiveness
- Ease of location, orientation, and gridding of APT pictures

d. Evaluate utility of Nimbus APT pictures for meteorological purposes.

4.1.6 GILMORE CREEK (ULASKA)

a. Complete in detail entire Nimbus APT pass summary and evaluation report for delivery to the APT Coordinator.

b. Evaluate APT station performance.

c. Evaluate utility of Nimbus APT pictures for meteorological purposes.

d. Evaluate low light level.

4.1.7 GILMORE CREEK (GILMOR)

a. Complete in detail the Nimbus APT pass summary and evaluation report, except items 17 through 21. Teletype report to NTCC for delivery to the APT Coordinator.

b. Evaluate APT station performance

c. Evaluate low light level.

4.1.8 PMR (PMRWEA)

a. Complete in detail entire Nimbus APT pass summary and evaluation report. NTCC will ensure delivery to the APT Coordinator.

b. Evaluate APT station performance.

c. Provide three copies of the received APT pictures to the APT Coordinator.

d. Evaluate utility of Nimbus APT pictures for meteorological purposes.

4.1.9 ALL KEY STATIONS

General instructions for all the key stations in phase I:

a. A ten-step grey scale is to be recorded immediately before and after each orbital pass. A copy of each is to be mailed to the GSFC APT Coordinator.

b. At least two Polaroid scope pictures are to be taken of the video signal horizontal trace on each picture at lines where fiducial marks are being swept. All pictures are to be identified by the station, orbit, data, frame number, and Polaroid exposure or shutter time.

c. All APT facsimile pictures are to be identified by the station, orbit, date, and picture start time.

d. All frames or partial frames for a respective orbit readout are to be kept together.

e. All data to be mailed to GSFC are to be mailed on a daily basis.

f. Each station is to accomplish a survey of "site-noise" prior to launch of Nimbus by checking all azimuth and elevation levels at 5-degree increments and recording receiver noise levels. Prior to each pass the antenna should be programmed through the expected azimuth and elevation values to record existence of any changes in site noise levels.

g. The magnetic tapes containing the recorded APT data during readout at WALACQ, ULASKA, and PMRWEA are to be forwarded to the APT Coordinator during phase I. During phase II the stations are to file the magnetic tapes pending release authorization from the NTCC after approval by the APT Coordinator and the APT Technical Officer.

h. Persons responsible for confirming that each of the key APT stations has the necessary equipment, material, and latest planning information and the specific stations to which they are assigned are as follows:

A. Riley	-	WALACQ, PMRWEA, ULASKA, AFCRLA
W. Risley	-	SFCAPT, RCAHNJ, GILMOR
E. Albert	-	WEABUR

4.2 PHASE II - OPERATIONAL EVALUATION

The second phase of the APT evaluation will begin immediately upon conclusion of phase I. During phase II, the Data Systems Division will prepare the first three parts of the Nimbus APT Daily Alert and Prediction (NADA) messages and send them to the APT Coordinator in NTCC for addition of Part IV. The APT Coordinator will return the NADA to Data Systems Division for formatting of Part IV. NADA's are then teletyped to NWSC for transmittal over the WMO telecommunications circuits.

The stations which will participate in this part of the evaluation are to complete the entire APT pass summary and evaluation report in as much detail as possible after each orbit and forward it to GSFC. The stations have been placed into two groups:

Group A:	WALACQ	AFCRLA
	SFCAPT	RCAHNJ
	WEABUR	PMRWEA
		ULASKA

Group B: All other APT ground stations in the worldwide network that agree to provide the APT pass summary and evaluation reports to GSFC

Group A stations are to complete the APT pass summaries and evaluation reports after each pass and teletype these reports to NTCC for delivery to the APT Coordinator. Group B stations are to complete the

APT pass summaries and evaluation reports after each pass and mail them to GSFC daily. Copies of these reports should also be mailed to the individual agency's headquarters as specified by the agency. Group B stations will not be required to provide Polaroid scope pictures or reproduced copies of the APT data.

Programming of the APT system during phase II, which continues throughout the life of the APT camera, will provide adequate exercise for all APT ground stations. Programming of APT readout will be as equally distributed as possible within the limitations of ground station location, proper solar elevation for TV photography, and power available. Instructions to use the high-gain antenna at WALACQ and ULASKA will be sent from NTCC by the APT Coordinator. The low-gain antennas are to be used for all passes unless specific instructions are received.

Figures VI-1, VI-2, VI-3, and VI-4 show orbits for the northern and southern hemispheres for the first 28 orbits.

5. APT PICTURE GRIDDING PROCEDURES

Details on proper orientation of Nimbus pictures, referencing their geographic coordinates, and meteorological interpretation, are furnished to the APT stations by NWSC.

5 1 MATERIALS FURNISHED BY NWSC

Materials furnished by NWSC are described briefly below.

5.1.1 APT REGIONAL MAP

A series of special transparent regional maps have been prepared for the Nimbus APT analysis procedure. These maps are drawn to the scale of APT pictures recorded on Fairchild facsimile. Five charts, at 50-km altitude intervals, have been provided for the range of altitudes expected with the Nimbus spacecraft. These maps show five-degree latitude and longitude lines; one-degree intersections are shown by dots.

Each APT station is provided with regional maps valid for the location of the station. Latitude lines only are labeled. The station position is indicated at the correct latitude, near the center of the map by the user. Values may be permanently assigned to the longitude lines.

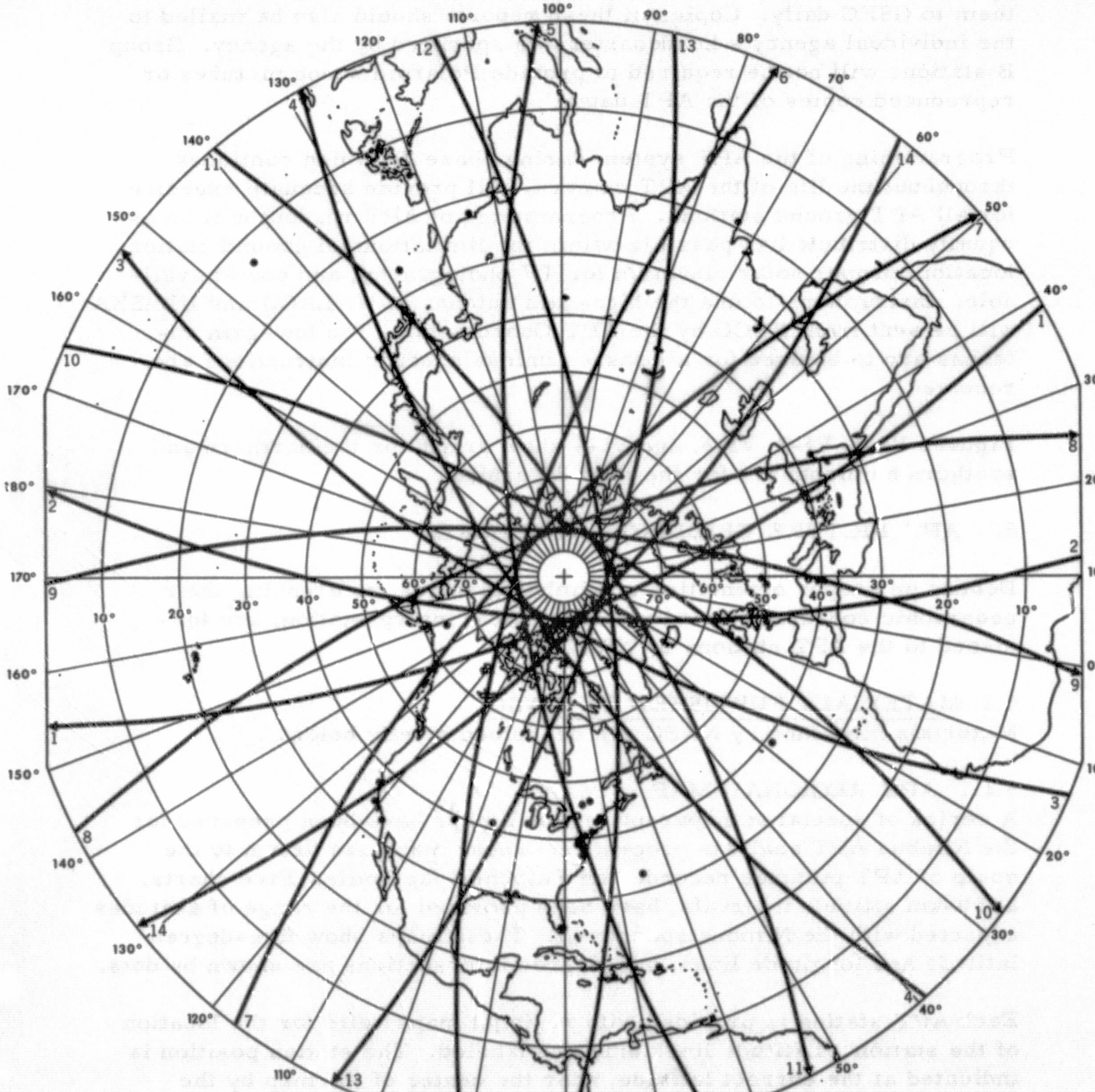


Figure VI-1 – Orbits 1 to 14, Northern Hemisphere

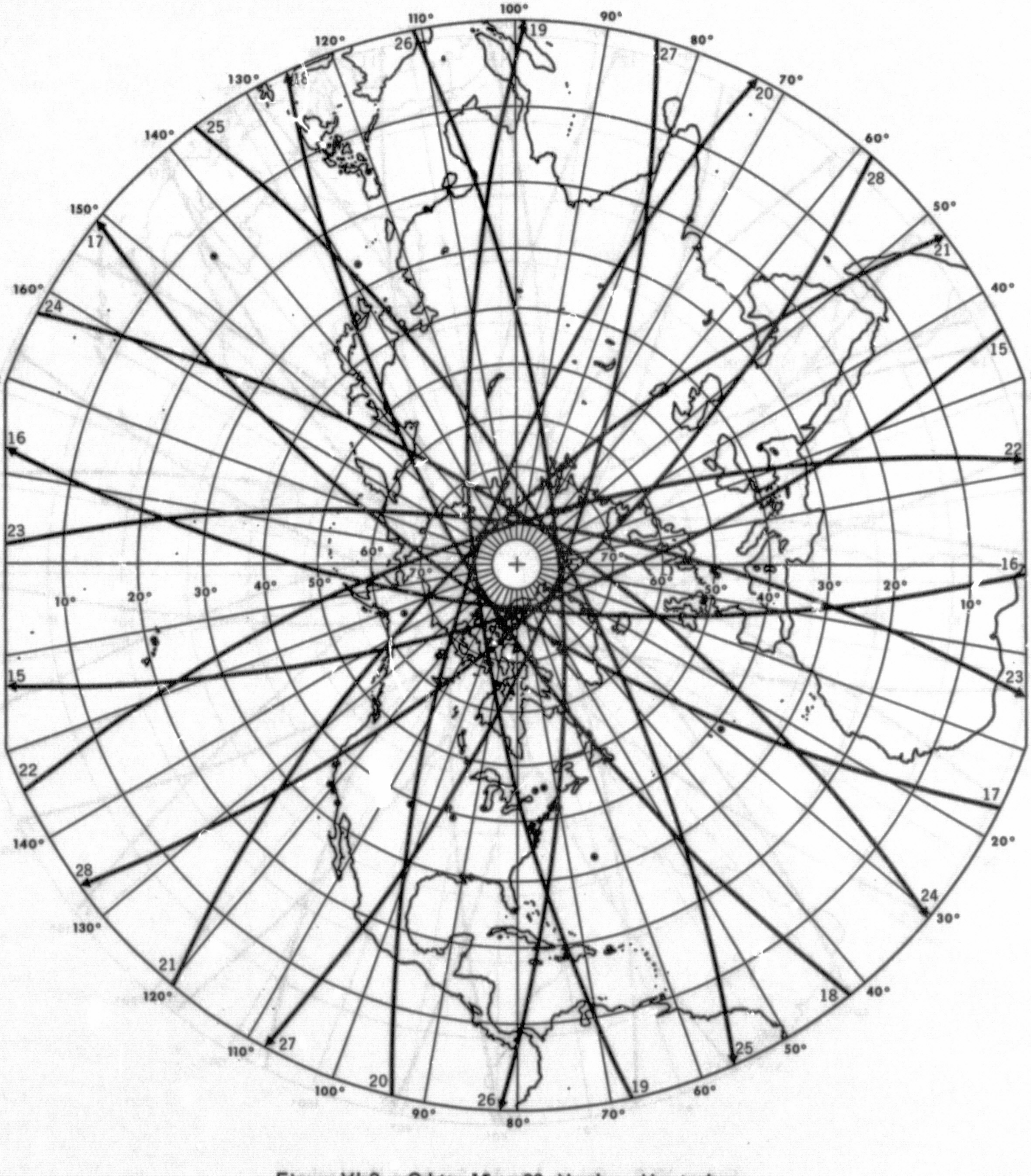


Figure VI-2 – Orbits 15 to 28, Northern Hemisphere

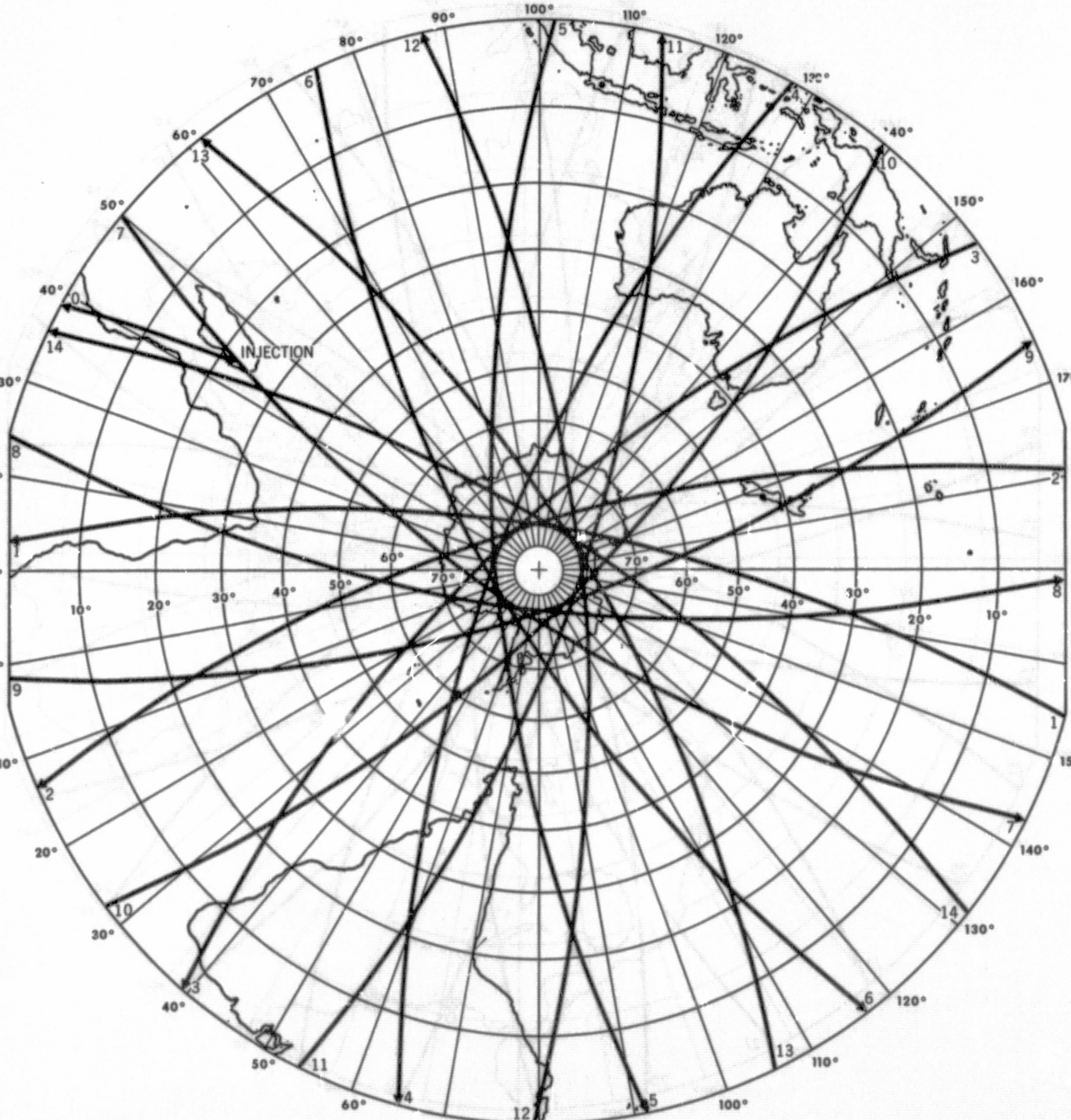


Figure VI-3 – Orbits 1 to 14, Southern Hemisphere

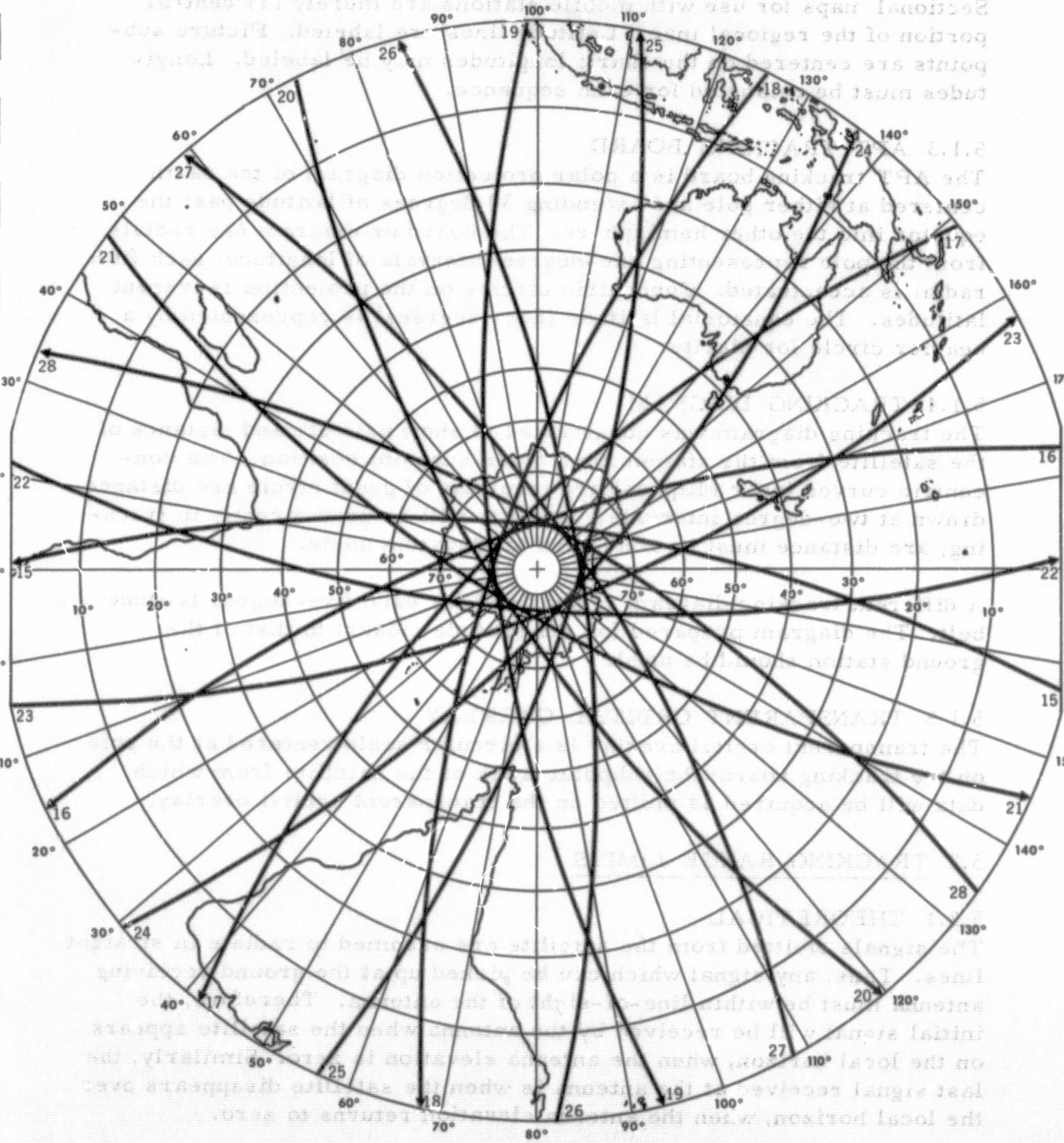


Figure VI-4 – Orbits 15 to 28, Southern Hemisphere

5.1.2 APT SECTIONAL MAPS

Sectional maps for use with mobile stations are merely the central portion of the regional map. Latitude lines are labeled. Picture sub-points are centered on the chart; longitudes may be labeled. Longitudes must be relabeled for each sequence.

5.1.3 APT TRACKING BOARD

The APT tracking board is a polar projection diagram of the earth centered at either pole and extending 30 degrees of latitude past the equator into the other hemisphere. The board or diagram has radials from the pole representing one-degree intervals of longitude; each fifth radial is accentuated. Concentric circles on the projection represent latitudes. The equatorial latitude (zero degrees) is represented by a heavier circle for clarity.

5.1.4 TRACKING DIAGRAM

The tracking diagram was constructed to show azimuth and distance of the satellite from the station for a given subpoint position. The concentric curves (near ellipses) are isopleths of great circle arc distance drawn at two-degree intervals. Azimuth will be used directly in tracking; arc distance must be converted to elevation angle.

A different tracking diagram is provided for each five-degree latitude belt. The diagram prepared for the latitude closest to that of the ground station should be used.

5.1.5 TRANSPARENT ORBITAL OVERLAY

The transparent orbital overlay is a circular scale centered at the pole on the tracking board; the subpoint track of the satellite from which data will be acquired is plotted on the transparent orbital overlay.

5.2 TRACKING RANGE LIMITS

5.2.1 THEORETICAL

The signals emitted from the satellite are assumed to radiate in straight lines. Thus, any signal which can be picked up at the ground receiving antenna must be within line-of-sight of the antenna. Therefore, the initial signal will be received by the antenna when the satellite appears on the local horizon, when the antenna elevation is zero. Similarly, the last signal received at the antenna is when the satellite disappears over the local horizon, when the antenna elevation returns to zero.

The local horizon of each acquisition station is represented by a zero-degree elevation circle on an azimuth elevation diagram. This zero-degree elevation circle is used to determine which orbits can be acquired by the local APT ground station.

5.2.2 EMPIRICAL

In all probability, the tracking antenna will not receive a usable signal from the satellite at zero degrees elevation. Local topography and elctronic interference will tend to increase the minimum elevation at which a usable signal can be received. Furthermore, it is probable that the minimum elevation for usable signal strength will not be constant for all azimuths.

The minimum elevation angle will have to be determined locally from experience. During the initial tracking exercises following launch the minimum usable elevation angle will be assumed to be two degrees. The antenna beamwidth is on the order of 20° to 30°, so that small elevation angle errors (or azimuth errors) will permit signal acquisition sufficient to track the satellite.

After the minimum usable elevation angles have been locally established, they will be used in place of the zero-degree elevation circles to define the equatorial longitude interval within which orbits can be tracked.

5.3 PICTURE ORIENTATION AND GEOGRAPHIC REFERENCING PROCEDURES

The following procedural steps are recommended to ensure a systematic analysis procedure for Nimbus APT pictures.

5.3.1 PREPARATION BEFORE RECEIPT OF DATA

5.3.1.1 Nonrecurring Preparation

Geography: Plot on the regional map: coast lines, lakes and other terrestrial features such as playas and mountain ranges which may be seen in satellite photos. Once drawn, these features need be changed only if it is found that the satellite view is different from the geographic outline in the atlas.

Example: The Nile Delta appears wider in TIROS photos than would be expected from looking at an atlas. Vegetation in the Nile Valley is quite dark in contrast to the desert sand so one must be aware that the river valley is seen rather than the river itself.

Heading Lines: Draw heading lines on the regional map. The heading line is the instantaneous projection of the satellite velocity vector on the earth. This is equivalent to the subpoint track on a nonrotating earth (a function of the orbital inclination to the equator).

The kit provided with the APT tracking board contains data in tabular form that will permit the user to plot heading lines on the regional map after orbital characteristics are known. Heading lines once on the map will be valid for the life of that spacecraft.

5.3.1.2 Daily Recurring Preparation

Plot on the regional map the predicted subpoint track for orbits where photographic data is expected.

When pictures are not to be taken on the reference orbit, it will be necessary to extrapolate the subpoint track for the orbits to be acquired.

Latitude of the subpoint for a given time after ascending node does not require extrapolation.

Longitudes must be extrapolated:

- Add the successive nodal increments (Part I) for the number of orbits between the reference orbit and the orbit to be acquired.

- Add this total increment to the longitude of the subpoints of the reference orbit.

The subpoint track on the regional map should describe a straight line. Points on the track will be evenly spaced when plotted for equal time intervals.

5.3.2 DATA RECEIPT

To insure receipt of contiguous data, APT pictures will be scanned so that the portion of the picture toward which the satellite is moving is received last.

With the exception of the polar regions during their summer season, the northern-most portion of the picture will be received last.

Determine picture time to the nearest one second during acquisition. It should be noted here that a 10-second error will result in a 40-mile positional error at the picture center.

Convert picture time (GMT) to orbital time relative to ascending node.

This time will be compatible with the subpoint plots on the regional map.

For pictures acquired north of the equator subtract equator crossing time from picture taking time.

For pictures acquired south of the equator subtract picture taking time from next equator crossing time, to give minutes before ascending node.

This time interval can never exceed one-third of the orbital period.

5.3.3 ANALYSIS STEPS

Subpoint Location

Find the picture subpoints on the regional map by interpolating linearly between plotted points.

Picture Principal Point

The Nimbus APT picture will have superimposed on it a grid pattern consisting of 25 fiducial marks. The picture center or principal point will be located at or near the center. Precise principal point position will be determined during camera calibration and disseminated at that time.

Geographic Referencing: Land Features Not Present.

Draw the forward heading line on the picture. Invert the picture after removal from fax so that the northern-most portion is toward the top of the page. Draw a line from the center fiducial to the top center fiducial.

Place the picture beneath the regional map so that the picture principal point and the interpolated subpoint are coincident and the forward heading line on the picture is parallel to the heading line on the map.

Geographic Referencing: Land Features Present

Place the picture beneath the regional map so that visible geographic features are located at their correct latitude and longitude.

Geographic Referencing: Attitude Bias

Detailed instructions to compensate for attitude bias, should it occur, will be given in Part IV of the daily message.

A permanent bias in roll or pitch will be compensated for by determining the true principal point on the earth at picture taking time and orienting the picture relative to this point.

A permanent bias in yaw will be compensated for by skewing the picture about the principal point at a predetermined angle relative to the forward heading line. The pictured elements will be displayed beneath the regional map at their correct geographic coordinates. Grid lines may be traced from the map to the photo directly at this point.

6. EQUIPMENT DESCRIPTION

The APT ground station system consists of a receiving antenna, cavity filter, preamplifier, FM receiver, and facsimile recorder (Figure VI-5). The APT FM signal is received at the APT station by a 13-db gain manually controlled helical antenna system (Figure VI-6). After amplification by a preamplifier at the antenna pedestal, the signal is fed to a facsimile recorder (Figure VI-7).

The facsimile recorder equipment must be started and the facsimile printout must be synchronized with the scanning beam of the vidicon; this is done during the 8-second period while the camera sensor is going through its prepare, expose, and develop (PED) cycle. At the beginning of the 8-second period, a 300-cps start tone, lasting 3 seconds, is transmitted to the ground. The tone signal automatically shifts the facsimile equipment from standby to the operate mode. During the next 5 seconds phasing pulses are transmitted to phase the facsimile equipment automatically. During the next 5 seconds pulses are transmitted to automatically synchronize the facsimile machine with the vidicon scanning beam. Picture printout follows, being built up line by line as it is scanned from the vidicon's storage layer.

When the satellite passes out of range of the APT ground station, the facsimile equipment reverts automatically to the standby condition.

6.1 ANTENNA AND PEDESTAL

The antenna is an 8-turn helix, 14 feet long and 27 inches in diameter, with a ground plane 72 inches in diameter. It has a beamwidth of 34 degrees at the half-power points and a gain of 13 db.

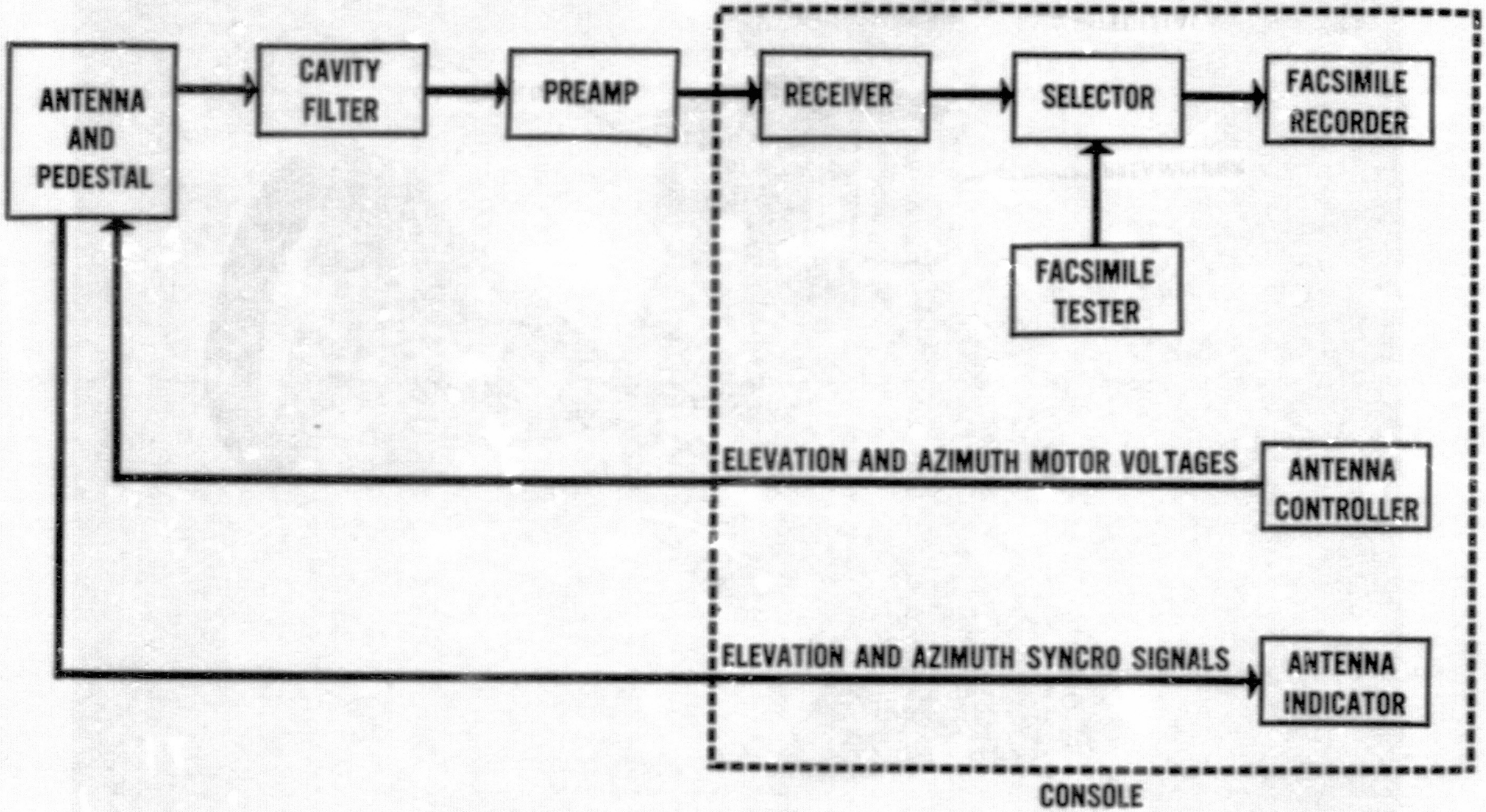


Figure VI-5 – APT Station, Block Diagram

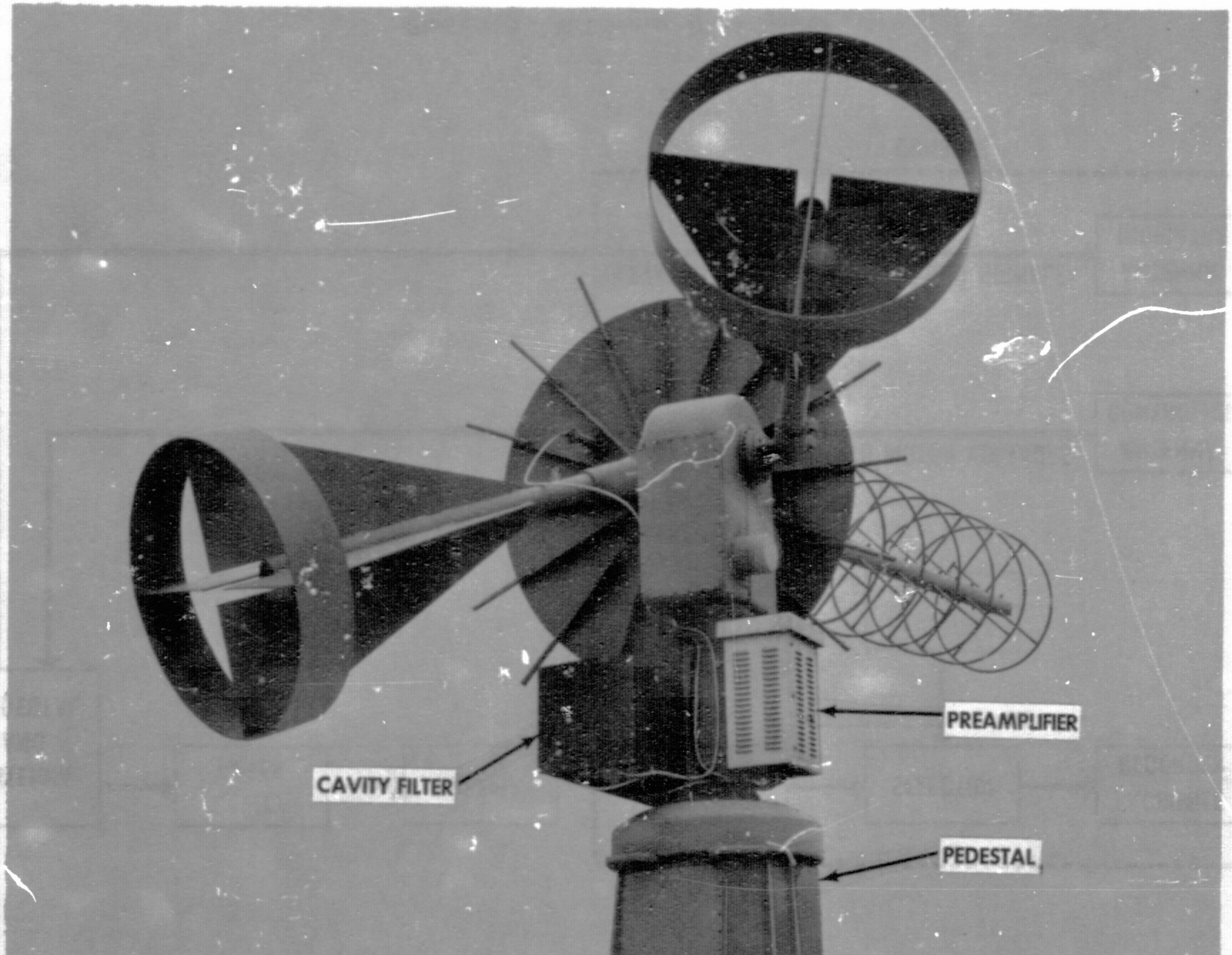


Figure VI-6 – APT Antenna

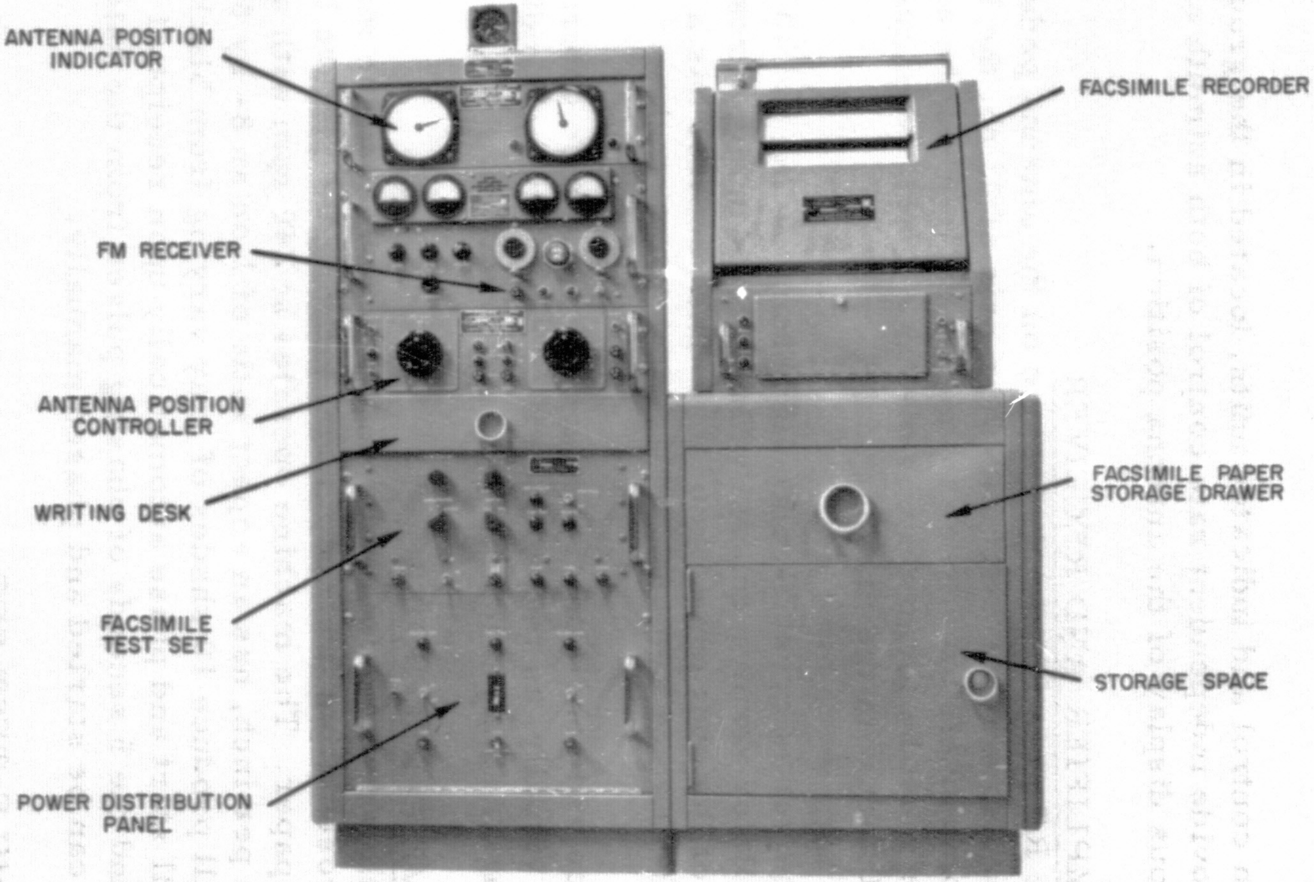


Figure VI-7 – APT Facsimile Recorder

The pedestal contains position motor drives, gearing, position synchro transmitter, and limit switches. It is capable of 720-degree rotation from stop to stop in azimuth, and 180-degree rotation (horizon to horizon) from stop to stop in elevation.

Total weight, including antenna counter-balances, is approximately 850 pounds.

The position control and indicator units, located in the ground station console, provide independent rate control of both azimuth and elevation and continuous display of the antenna position.

6.2 PREAMPLIFIER AND RECEIVER

A two-stage RF preamplifier is located on the antenna pedestal. The preamplifier has a 5-Mc passband and a gain of 22 db, the latter required to compensate for losses in the RF cable when the antenna and the receiver must be located some distance apart. Maximum separation is 1,000 feet with the present scale.

The FM receiver is crystal-controlled from 130 Mc to 140 Mc, with a second oscillator vernier control which allows tuning across 150 kc on either side of the operating frequency. The receiver has a selectable bandwidth of 50 kc or 100 kc.

The presence and condition of the input signal can be determined both aurally and visually, as the unit has a speaker and four indicators; signal strength, tuning, video output, and deviation.

6.3 FACSIMILE RECORDER

The facsimile recorder is a helix and writing-blade type machine, using electrosensitive (wet) paper and forming the picture by depositing ions on the paper. The machine operates at 240 rpm with a resolution of 100 lines per inch, has an aspect ratio of 1 on an 8- by 8-inch format, and will produce 10 shades of gray varying from black to white. The unit will start and phase automatically upon receipt of the 300-cps start tone and the 5 seconds of phasing pulses from the satellite equipment, or it can be started and phased manually.

6.4 FACSIMILE TEST SET

The facsimile test set provides the necessary signals to the facsimile equipment for checking its proper operation. These signals include start tones, phasing, pulses, resolution patterns, and gray shades.

6.5 TEST SIGNAL SOURCE

The test signal source is a small lightweight portable transmitter designed to test the RF portion of the ground-station system. The unit is battery-operated with a pullout antenna for field use.

The transmitter operates at the 136.950-Mc carrier, frequency-modulated with a 2400-cps signal, and has a power output of 5 milliwatts. When using this unit, one shade of gray will appear on the facsimile recorder. The unit is also provided with a connector so that its signal may be plugged directly into the preamplifier or the receiver.

6.6 CONSOLE

The console also has a pullout writing desk on the left side, and a thermostatically controlled storage drawer under the facsimile recorder for the electro-sensitive paper to prevent the paper from freezing if the ambient room temperature drops below 30°F.

PART VII

USWB DATA UTILIZATION PLAN

The U.S. Weather Bureau's (USWB) National Weather Satellite Center (NWSC) at Suitland, Md., will participate in data-utilization and archiving for the Nimbus project. The NWSC Data Processing and Analysis Facility (DAPAF) is the central NWSC operating unit that will use data from the Nimbus mission. The equipment facilities are described briefly in section 4 below.

NWSC activities include:

- Weather forecasting
- Research and development functions
- Archiving of meteorological and certain telemetry data and the AVCS master film

NWSC will make available real-time meteorological products which will increase the capability of the forecaster and climatologist to meet the needs of the using agencies. The initial products will be pictures, digital mosaics, grid point data, and teleprinted information. During the research and development phase the archived and operational data will be used to increase the understanding of the sun-earth system and the interactions which result in short- and long-range weather phenomena. Techniques for optimum use of existing meteorological satellite data for improving routine forecasting will also be investigated. The archiving of meteorological data will be accomplished in a manner to permit optimum storage of large quantities of data and rapid manual and automatic information retrieval. The archival center for the USWB is the National Weather Records Center (NWRC), Asheville, N.C. The meteorological community may obtain copies of archival material from NWSC at cost.

1. PRELAUNCH OPERATIONS

NWSC will participate in prelaunch tests of communication terminals and the data-processing facilities. These tests will be used to determine the capability of DAPAF to perform its mission in rapid processing of operationally usable meteorological satellite data.

The test of the DAPAF capability will be performed in conjunction with the microwave terminal and the overall communication system checkout. DAPAF, during these communication test periods, will process the data in real time and produce the output that would normally be transmitted to the users. When the wide-band long-line system is in operation the final products for transmission will be digitized mosaics and kinescope-produced pictures of the video information. During this period the 3-kc facsimile line and backup communication system will also be checked. Manual nephanalysis will be prepared at the DAF station and transmitted over the 3-kc facsimile communication system to NWSC via NTCC. The frequency of preparation and transmission will be the same real-time mode as prescribed for the terminal tests. The Westrex Photo Facsimile will also be tested in the same real-time periods. The photos received by the Westrex facsimile system and the DAF-produced manual nephanalyses will be given in-house processing by the manual-analysis team and prepared for transmission on a real-time basis.

2. POSTLAUNCH OPERATIONS

Postlaunch operations include the initial activation phase and routine operations.

2.1 INITIAL ACTIVATION PHASE

The responsibilities of NWSC during the activation phase include determining the effectiveness of the data-utilization system and the reliability and operating status of:

- NWSC data processing complex
- Communication system
- All modes of operational meteorological data handling

To accomplish these tasks the communication system from the NTCC to the output stage at NWSC will be checked by the NWSC manual analysis team. After launch and during the initial activation period NTCC will monitor the communication system.

Direct readouts can be taken on orbits in which the spacecraft crosses over the United States, and will permit communication, gridding, attitude, timing, camera-equipment, and operational checks of the NWSC complex under the normal operating mode.

2.1.1 AVCS DATA PROCESSING

During normal operating on orbits over North America the manual analysis team of NWSC can compare the analog and digital video cloud cover with conventional hourly data from United States and Canadian weather observing stations in the swath area. The gridded kinescope pictures will be compared with the conventional data for location, intensity, and pattern of cloud formation. The gridded digitized manually annotated computer output will be compared with conventional data for location, intensity, pattern and interpretation of the types of cloud formation. In addition to surface observations, upper air sounding data, radar data, etc., will be used in the checkout. These tests will constitute the initial evaluation of the quality and the operational utility of the DAPAF video output.

2.1.2 SUPPORT OF HRIR VALIDATION

NWSC is prepared to support the GSFC validation of HRIR data before making the data available to the meteorological community. GSFC will validate all HRIR data received. However, best results are expected from those orbits which will give information over parts of Europe and over the United State· here the conventional meteorological stations are plentiful and the data most reliable. All available forms of conventional data will be used in the validation. During the validation period the normal mode of HRIR data processing will be followed, but no data will be released.

2.1.3 VERIFICATION OF SENSOR CALIBRATION

Prelaunch sensor calibration will be supported by the NWSC meteorological personnel assigned to the Nimbus project. The HRIR, AVCS, and PCM subsystems will be given calibration tests by the Nimbus project to ensure that operational standards are attained.

During the activation phase NTCC will monitor the telemetry of the AVCS, HRIR, and other subsystems to determine actual operating conditions and will report abnormal conditions affecting the output of the meteorological or other sensors to the DAPAF supervisor.

A combined manual and automatic analysis procedure will be followed at DAPAF to verify the prelaunch AVCS distortion calibration and to discover any environmentally induced variations. Raster size, centering, and linearity changes may be anticipated as a result of the launch shock and the earth's magnetic field. Careful study of system parameters and the image positions of known landmarks will allow analysis of these raster variations. Verification of AVCS photometric

calibration in a quantitative sense is possbile only with respect to the self-calibration grey scale. The video response for each grey-scale step may be compared in prelaunch and postlaunch pictures. HRIR calibration will be verified during validation by GSFC.

2.2 ROUTINE OPERATIONS

The NWSC DAPAF complex is in a normal operating mode when a single-orbit operation exists. The data will normally be received, collated, evaluated, and routed through the NWSC complex and to the meteorological community within about 100 minutes of acquisition from the spacecraft. Figure VII-1 shows the data flow through the NWSC complex; paragraph 4 below describes the equipment.

Modifications of operating procedures are required when any of the following conditions exist:

- Double-orbit acquisition
- Microwave link failure
- DAPAF computer complex inoperative
- NDHS CDA 924 computer(s) inoperative

2.2.1 INPUT DATA

The NWSC DAPAF will receive operational meteorological data from NTCC in the form of AVCS, HRIR, and certain processed telemetry data. Both analog and digital data will be received over two 48-kc communication bands via landline and microwave. In addition, selected rapid processed pictures will be received over the SCAMA 3-kc facsimile circuit. In case of microwave failure, manual nephanalyses will be made by the DAF-assigned USWB meteorological team.

Archival data will be received by mail. The 14-channel Mincom magnetic tape containing AVCS and HRIR data will be forwarded weekly from the DAF station. Teletype and voice messages from the DAF station will be used as required.

Ephemeris data are received from GSFC prior to the initial acquisition of meteorological and other support information at NWSC from the most recent orbit. Smooth attitude and meteorological parameter data are received in digital form from the DAF station in accordance with the mode of operation in effect at the time.

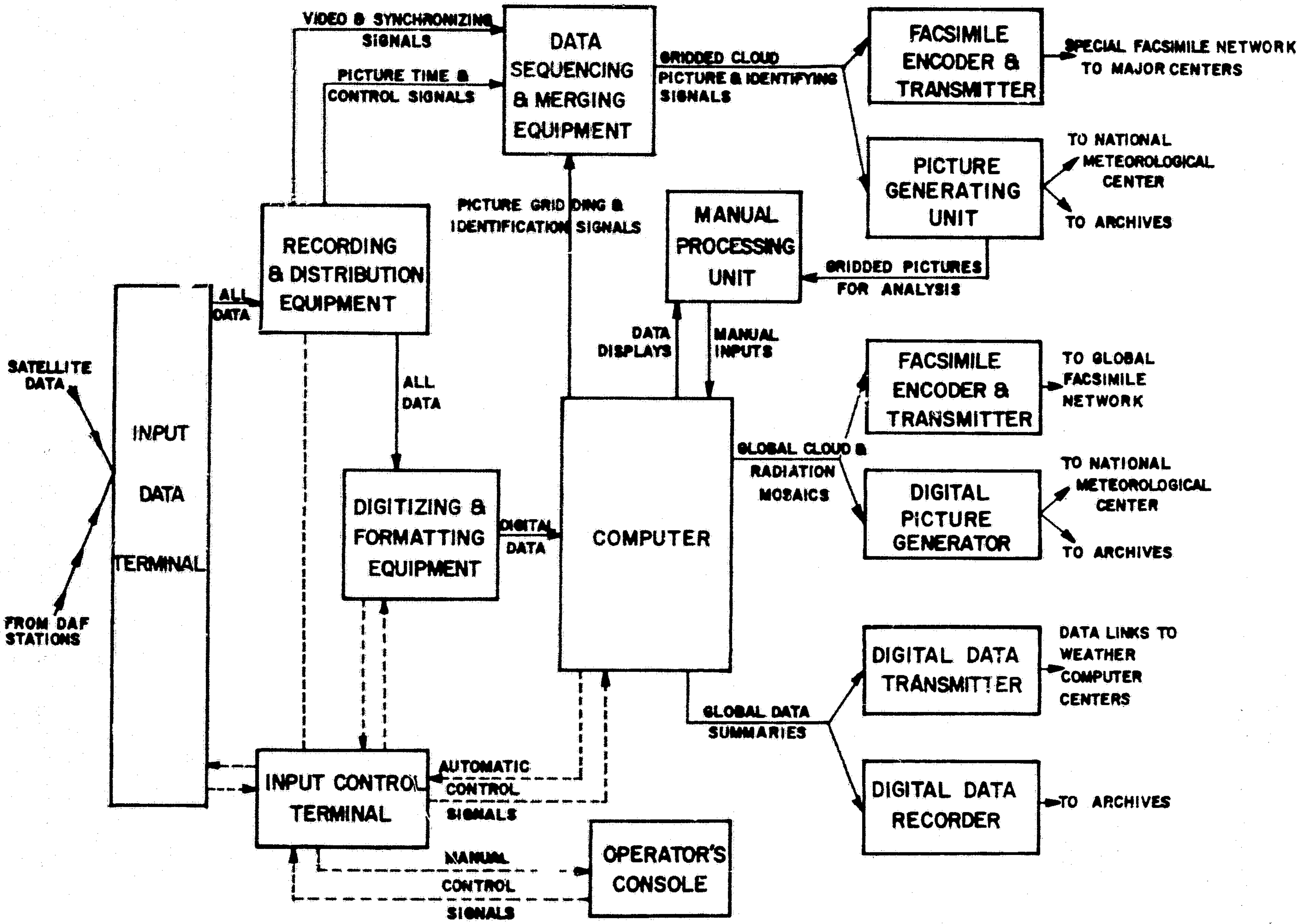


Figure VII-1 — NWSC Data Processing System

These data are combined in the NWSC computer complex with picture time data in the preparation of AVCS and HRIR gridding and digital rectification.

2.2.2 PROCESSING AVCS DATA

AVCS data will be received at NWSC in the form of analog signals at a rate of 7.5 ips (Figure VII-2). During receipt of this 1/8-speed replay of the AVCS pictures, two essentially parallel paths are followed through the NWSC complex.

On one path, the data from the loop recorders are sequenced and merged for play into the kinescope reproduction system at a speed-up of 8:1. Channel and recorder sequencing is under computer control. Gridding signals and special legend data may be recorded on the loop tape recorders in synchronism with the video data. Seventy-millimeter film strips will be produced by the RCA cameras and rapid processors for operations picture production. The first picture will be available approximately 1 1/2 minutes after initial receipt of data. Picture data will be used locally for checking the digital analysis, National Meteorological Center (NMC) use, and selective transmission to the meteorological community. A 35-mm film is also produced by kinescope camera equipment and is used for archival and operational backup purposes.

The video signals on the second path are recorded at 7.5 ips on tape recorder. The FM signal is played back at 30 ips to the Ess Gee equipment.

2.2.3 PROCESSING HRIR DATA

Since the HRIR subsystem to be flown on Nimbus A is experimental, it will be necessary to establish the validity of the data obtained before they can be used (Figure VII-3). A validation program has been prepared by the GSFC HRIR Experimenter, W. Nordberg, to determine whether:

- The internal functioning of the radiometer conforms to performance criteria established in preflight tests

- The radiometer is capable of radiation-pattern mapping, i.e., the radiation patterns shown on HRIR output products conform in size, shape, orientation, and location to cloud-cover patterns or surface-temperature patterns in cloud-free areas

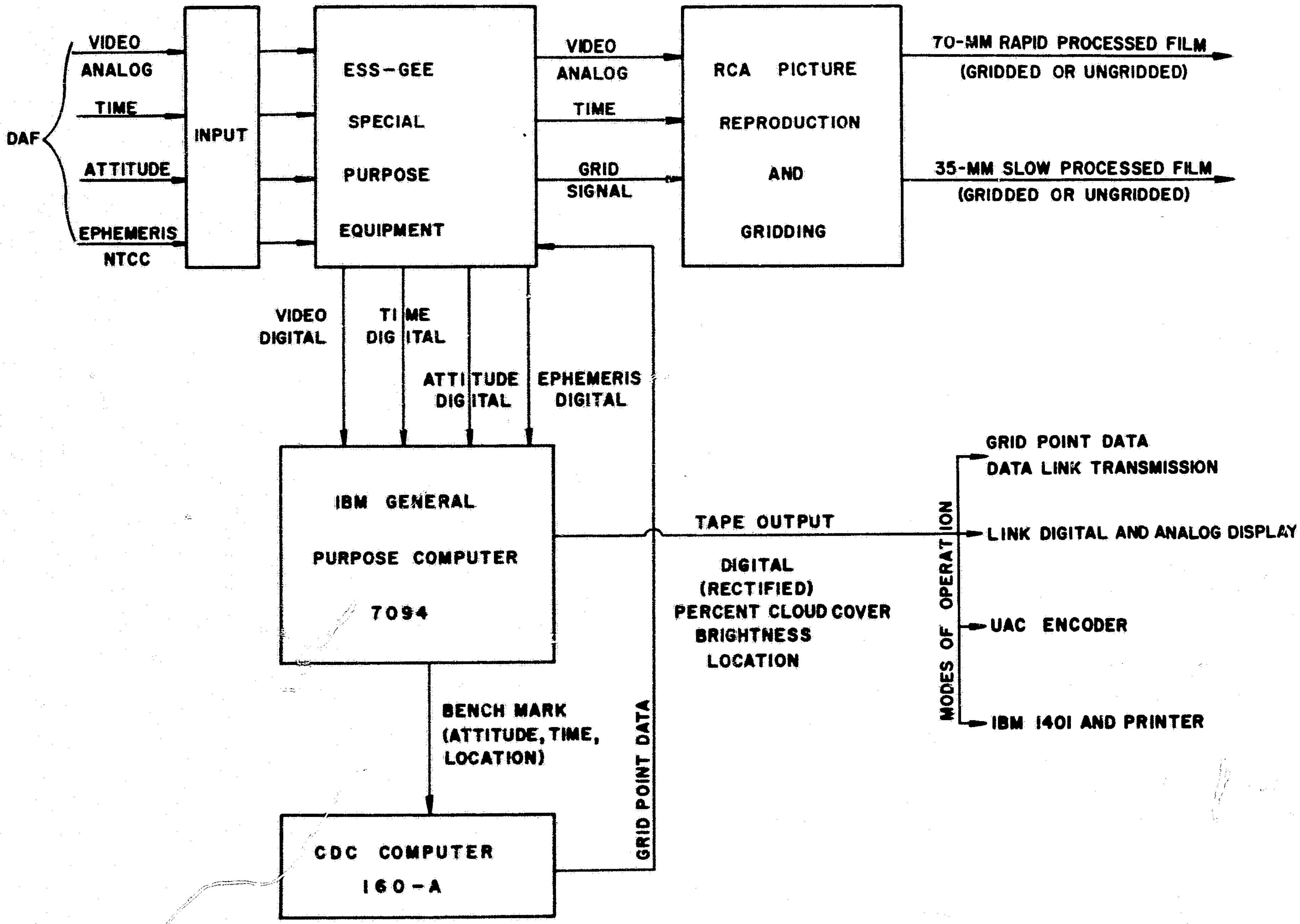


Figure VII-2 – AVCS Data Flow, Block Diagram

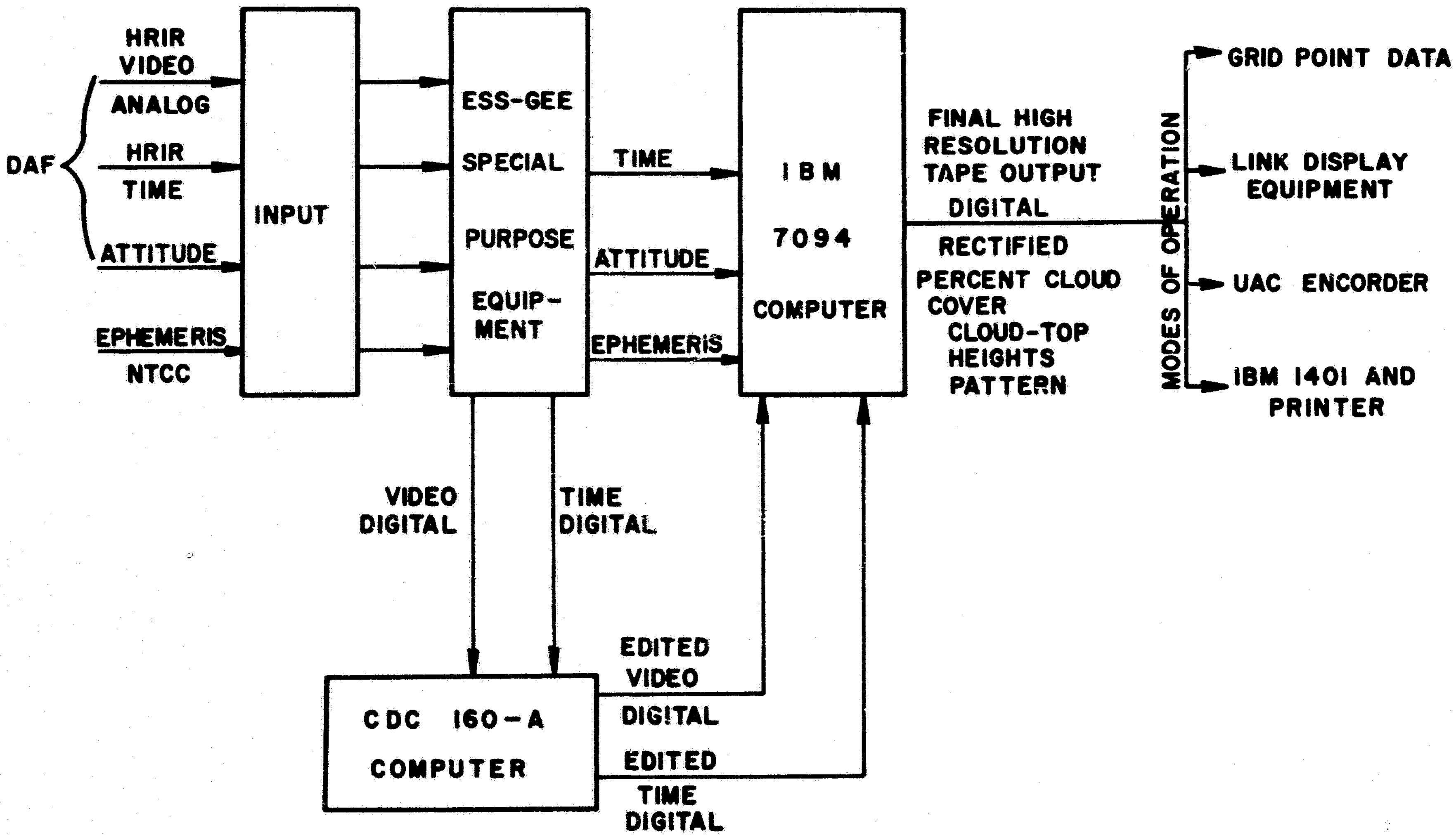


Figure VII-3 – HRIR Data Flow, Block Diagram

- The data content of the HRIR output is meaningful, i.e., the sensitivity and dynamic range of the radiometer conform with preflight calibration data, the radiometer is able to respond to various signal levels, and the output equipment (both analog and digital) is able to depict these signal levels appropriately, at least on a relative-intensity basis

When these three criteria have been verified by the GSFC HRIR Experimenter, DAPAF will begin preparation of experimental cloud-pattern maps in quasi-real time from HRIR data received from NTCC.

HRIR data are recorded for about 60 minutes of the total 103 minutes required for a complete orbit. Copies of these data are received at NWSC in the form of analog signals; certain associated telemetry information is received in digital form. The four processing stages through which the HRIR data passes at NWSC before distribution are:

- Ingestion
- Melding
- Digital formating
- Output

In the ingestion stage the HRIR analog data are converted into digital form. The data are fed into a computer complex which produces an intermediate data tape. During this process the data are edited and only that portion of each scan which views the earth is retained. This amounts to about a third of the available data.

During the melding stage a final meteorological radiation tape (FMRT) is developed. The edited data from the CDC 160 A are combined with telemetry data and ephemeris information to give the earth location and value of any HRIR data in terms of latitude, longitude, time and physical units.

By combining the HRIR data with conventional meteorological data and/or climatology, the following three parameters of cloud information can be mapped:

- Percent cloud cover
- Cloud heights
- Pattern index

Maps of these parameters are experimental products; their actual contents will depend on the results of validation. The mapping procedure will summarize data at grid points. The tapes generated will vary in accordance with the parameter mapped and the analog device used in the output stage.

The output, depending upon transmission capability, will be either digital or visual. Digital products may be in the form of FMRT or grid point data tape. If the output is visual, rectified maps will be transmitted over the facsimile circuit.

Magnetic tapes containing HRIR data will be mailed to NWSC from the DAF station. These data will also be processed through the DAPAF equipment, and the maps produced will be compared with the quasi-real time maps. The better product of the two will be archived by photographing the maps on 35-mm film for permanent storage and/or duplication. The photolab will perform the photography and subsequent processing.

As part of the HRIR validation program, efforts will be made by GSFC HRIR Experimenter to assign absolute values to the HRIR data, either in terms of the temperature of the radiating surface or in terms of the energy emitted from each data point. The resultant output, recorded on magnetic tape, may be stored for an indefinite period. Exact archiving procedures for these data have not been determined. The Documentation Section at NWSC will maintain records, publish catalogs, and process requests for HRIR archival material recorded on photographic film and possibly on magnetic tape too. Copies of all experimental HRIR data processed at NWSC will be made available to the GSFC HRIR Experimenter.

2.2.4 MANUAL ANALYSES OF DATA AT NWSC

In the normal DAPAF operations the digitized output will have a resolution of approximately 20 to 30 miles, depending upon latitude, in at least two outputs: (a) percent cover, and (b) brightness.

Using manual messages of the digitized outputs, one final analysis will be prepared. The manual analysis team will use the rapid processed kinescope pictures, conventional meteorological data and climatology to annotate the digitized output. The analysis team will add cloud detail and notations to increase the meteorological information available from the digitized computer output.

After manual processing, distribution will be by facsimile and teletypewriter modes.

2.2.5 PRODUCTS DELIVERED TO THE USERS

Products delivered to the user are in one of the following four modes:

- Grid point data (tape-to-tape)
- Facsimile products
- Selected pictures
- Teleprinted code data

These products are derived from (1) manually annotated digital computer printouts; (2) full resolution perspective gridded pictures; (3) graphical nephanalyses; (4) computer generated tapes of mapped cloud data; (5) FMRT; and (6) coded analysis of cloud distribution data.

2.3 EMERGENCY OPERATION PROCEDURES

Emergency operation procedures will be followed when the flow of data through the system is not in the normal operating mode.

2.3.1 CDC 924 FAILURE

If there is only one CDC 924 computer operating at the DAF station, there will be a delay of approximately 15 minutes in the receipt of the data at NWSC. The delayed data receipt will result in a comparable delay in the product output of the DAPAF facility. There will not be any change in the internal operations of the facility.

In the unlikely event that both computers at the DAF station are inoperative, the station can produce only ungridded HRIR and AVCS data. No PCM data will be available. Therefore, zero attitude correction or a constant error will be assumed and the attitude data from the latest orbit will be used. The AVCS and HRIR data will be received at NWSC earlier than in the nominal two-computer case and the data will be gridded in the DAPAF computer complex.

2.3.2 DOUBLE-ORBIT ACQUISITION

In the double-orbit acquisition operation no change will be required at NWSC in the processing of data from the most recent orbit. For the earlier or stored orbit no PCM data will be available; therefore, zero attitude correction will be used or a constant error will be assumed

and the attitude data from the latest orbit used. Although AVCS transmission for the double orbit will take longer than for a single orbit, DAPAF processing of the data can continue uninterrupted into the stored orbit until the next acquisition takes over. This should allow all but the earliest portion (that taken in the southern hemisphere) of the stored orbit to be processed.

The HRIR double-orbit problem is more complicated, but it should be possible to send data to NWSC.

2.3.3 DAPAF FAILURE

DAPAF failure can signify partial or total failure of the facility. Total failure of the facility includes failure in special-purpose input and output devices. If there is total failure, no digital rectifications are prepared. Only manual nephanalyses prepared at the DAF station and annotated at NWSC will be available for distribution to the meteorological community. Only selected kinescope produced pictures transmitted from the DAF station will be available for internal use and photofax distribution.

Partial failure of the facility can take many forms, but only failure in the operation of major units will be discussed here. Failure of the IBM 7094 computer will necessitate an output similar to that of total failure. Local kinescope video data will be available for internal use and photofax distribution. The manual nephanalyses will be prepared at the NWSC facility by the manual analysis team for further distribution.

Inoperation of the CDC 160 A computer will mean that no HRIR data will be available from DAPAF and that the gridding for the video data will be accomplished by the IBM 7094. There will be no change in the digital or analog video output.

During periods when the Ess Gee equipment is inoperative no digital or analog data will be produced locally. DAF station manual nephanalyses will be available for video and HRIR data. Selected DAF processed video pictures will also be available for internal and photofax output transmission. If either the input or the output transmission is inoperative, there will be no output from DAPAF.

2.3.4 WIDEBAND LINK FAILURE

When the wideband link is inoperative, slow-speed video signals and HRIR data cannot be transmitted from the DAF station. Nephanalyses and selected pictures will be received at NWSC during this interval.

This information, properly annotated at NWSC, will be available for distribution to the meteorological community. Selected kinescope produced pictures received from the DAF station will be distributed over the photofacsimile system.

3. ARCHIVING FUNCTIONS

It is the responsibility of NWSC to process Nimbus A meteorological data into forms which are suitable for: (1) permanent storage at the National Weather Records Center (NWRC), Asheville, N.C., and (2) rapid, economical, duplication for dissemination to interested users.

For the great bulk of the data, the storage medium selected to satisfy these requirements is a photographic image on silver halide film. Original master negatives, produced under rigid quality control, have extremely long life, especially when they are properly stored and are used only infrequently to generate master positives. These positives are used to produce both working negatives for routine distribution and second-generation master negatives which, in turn, are used to produce working positive copies.

All original master negatives will be produced on 35-mm film, which lends itself well to subsequent duplication with standard equipment and permits storage of a large amount of data in relatively small physical area. However, since the standard unit of 35-mm film is the 100-foot length, equipment has been procured for the NWSC photolab which will print up to 99 reduced-size pictures with appropriate legends for documentation on an 8 1/2 by 11-inch sheet of cut film. These composites, called unit record sheets, will normally be used to present all of the AVCS pictures from one pass on one sheet of film. Working duplicates can be made rapidly and inexpensively from silver halide unit record masters by a diazo process.

In general, magnetic tapes will not be used for permanent data storage because of their relatively short life, their large physical volume, and the large capital investment. Soon after the data have been extracted and recorded on photographic film for archival storage, most of the magnetic tapes will be degaussed and reused. Undoubtedly a few tapes will be held at NWSC for some months, or even years, for use in certain research operations; but these, too, will eventually be reused.

3.1 ARCHIVAL INPUT DATA

Although the input data will not be permanently stored in their initial

form, it is desirable to identify the items that will be used in the production of archival products. This material will be delivered to NWSC as scheduled by NTCC.

- AVCS and HRIR video and time signals transmitted to NWSC over the microwave longline from NTCC
- AVCS and HRIR video and time data on magnetic tapes mailed to NTCC/NWSC
- AVCS film mailed to NTCC/NWSC
- Attitude and other telemetry parameters transmitted to NWSC over the microwave longline from NTCC
- Predicted orbital parameters (ephemeris data) generated at GSFC and transmitted to NWSC via teletype
- Updated (i.e., improved accuracy) attitude and/or ephemeris data that become available from any source, such as the DAF station, GSFC, or DAPAF
- Documentation (legend) data generated by DAPAF to identify the various archival products

3.2 ARCHIVAL PROCESSING OF AVCS DATA

Inherent characteristics of the two subsystems dictate that the archival processing of AVCS data will be somewhat different from that of HRIR data. The three NWSC activities directly in processing AVCS data are DAPAF, the Photographic Laboratory, and the Documentation Section.

3.2.1 DAPAF

DAPAF will process the input data through its computer complex and ancillary equipment to generate:

- Photographs on 35-mm film of cloud patterns displayed on kinescopes, commonly termed "AVCS pictures." Two sets of pictures will normally be produced for each pass. One set will have a latitude-longitude grid electronically melded into each picture; the other will be upgridded. Bare grids can also be produced if desired. A legend indicating pass, frame, and camera numbers, shutter time, location, etc., will be generated and will be recorded on the film adjacent to each picture. Actually, DAPAF will

produce just the exposed 35-mm film, which will then be developed by the photolab to give original master negatives.

- Digital magnetic tapes produced operationally (in quasireal time) by the computer complex using input data received from the DAF station via the longline. These are designated as "computer output tapes," and contain the following parameters: (1) percent cloud-cover, (2) average brightness, (3) cloud pattern, (4) the location at which the foregoing parameters obtain. These magnetic tapes will be stored at NWSC for an indefinite period. Duplicate copies may be made from them for research uses. Eventually the tapes will be degaussed and reused.

- Digital mosaics produced by playing the computer output tapes through one or more of the following equipments: (1) an IBM 1403 printer, (2) a cathode ray tube and associated camera to photograph the display, (3) a facsimile printer (after intermediate processing through a special encoder), (4) a line plotter. Manual annotation will probably be added to these mosaics after they are compared with kinescope photographs and conventional meteorological data. The annotated mosaics will be stored for an indefinite period at NWSC and will also be photographed for permanent archiving at NWRC.

3.2.2 PHOTOGRAPHIC LABORATORY

The photolab will process AVCS pictures, starting with the exposed 35-mm film produced by DAPAF. These pictures will be produced in both gridded and ungridded form and may or may not have undergone electronic contrast modification to bring out certain details of cloud structure. Further, if the electronically melded grids appear to be unsuitable for certain purposes, bare grids can be photographically superimposed on ungridded pictures.

The photolab will also photograph on 35-mm film and process for storage and/or duplication those digital cloud-pattern mosaics produced by DAPAF that require archiving. Original master negatives will be stored at NWRC, and duplicate masters will be held at NWSC for production of paper or film prints.

3.2.3 DOCUMENTATION SECTION

Using records or logs of DAPAF and photolab activities and products, the documentational section will:

- Prepare catalogs of AVCS data in the various forms that will be available to users
- Store NWSC's working positives and also duplicate copies of AVCS pictures or digitized mosaics
- Fill requests for duplicates from their stocks, or request the photolab to produce such copies as required
- Maintain files of photolab products
- Maintain records of other pertinent information, such as iris settings on AVCS pictures, quality of photographs, and unusual meteorological phenomena recorded in various picture sequences

3.2.4 INITIAL DISTRIBUTION

The AVCS archival-processed data is initially distributed to the following:

AFCRL:	2 viewing positives, 2 duplicate negatives
NWRF:	1 viewing positive, 1 duplicate negative
GSFC:	1 viewing positive, 1 duplicate negative
NWRC:	1 master positive, 1 duplicate negative
NWSC:	1 master positive, 1 archival negative, 1 viewing positive

4. NWSC FACILITIES AND EQUIPMENT

NWSC facilities include DAPAF and the Photographic Laboratory.

4.1 DAPAF

The design of the DAPAF facility permits maximum flexibility in data formats for both input and output. The data-utilization system has two basic modes. In the operational mode, data flow through the system within approximately 100 minutes of acquisition from the satellite. In the archival or research-support mode the data move more slowly. Archival processing will be governed by the physical receipt of the 14-channel Mincom magnetic tape from the DAF station and by the final orbit determination. The magnetic tape will be shipped weekly from the DAF station.

4.1.1 DATA TERMINAL EQUIPMENT

The Telpak B X-108 terminal at NWSC provides means for receiving data from a DAF station and GSFC. The AVCS, HRIR and time signals received operationally from a DAF station are routed directly from the terminal to the ESS Gee equipment described below. Digital data received from NTCC are recorded on an IBM computer magnetic tape. This tape must be manually transferred to a computer tape drive for further processing. The X-301 C may also be used to transmit digital data from the DAPAF to the other terminals.

4.1.2 ESS GEE EQUIPMENT

The Ess Gee equipment's prime function is to format the input data. On-line computer processing of data is made feasible through the use of bin storage tape recorders as speed buffers. The system is flexible and modular in design to permit an expanded capability for processing of increased data rates or additional channels of meteorological satellite information. The Ess Gee equipment includes 22 racks and a control console. The racks include:

Rack #1 - Mincom Monitor Tape Recorder #2
Rack #2 - Mincom Monitor Tape Recorder #1
Rack #3 - Switching Unit #1
Rack #4 - Sangamo Loop Tape Recorder #5
Rack #5 - Sangamo Loop Tape Recorder #6
Rack #6 - Sangamo Loop Tape Recorder #7
Rack #7 - Data and Reference Discriminators
Rack #8 - PCM Demodulator and Time Code Converter
Rack #9 - Sangamo Bin Tape Recorder #3
Rack #10 - Bin Electronics for Tape Recorder #3
Rack #11 - Sangamo Bin Tape Recorder #4
Rack #12 - Bin Electronics for Tape Recorder #4
Rack #13 - & 14 - Control Logic Self Test Units
Rack #15 & 16 - System Power Supply and Control Units
Rack #17 - Synch Detectors and Switching Units
Rack #18 - Simulation Equipment
Rack #19 - Multiplexer and Analog-Digital Converter
Rack #20 & 21 - Format Control Units
Rack #22 - Character Generator
Parallel to Serial Converter
Serial to Parallel Converter
Character Control Unit

The Control Console includes controls for the following units and functions of Data Acquisition and Processing System:

1. Tape recorders
2. Power supply control
3. Program control
4. Command function
5. Monitor scope
6. Grid disable
7. Time display

4.1.2.1 Tape Recorders
A total of five tape recorders is used operationally in the system. Two additional recorders are used for backup purposes and functions not associated with real-time data processing.

a. Reel-to-Reel Recorders—TR 1 and TR 2 are standard Mincom reel-to-reel analog tape recorders. TR 1 is a 14-track unit and TR 2 has 7 tracks. These recorders are used to monitor the AVCS, HRIR, and time data transmissions from the DAF station and are "fed" directly from the AT&T terminal equipment. These recorders will provide a record of received data should equipment breakdown cause lost data or delayed processing in the DAPAF complex. Track assignments on TR #1 will be similar to those made at the DAF station, to facilitate archival replay of magnetic tapes originally recorded at a DAF station. TR #2 may be used as backup for TR #1 during real-time operations.

b. Bin Storage Recorders—TR 3 and TR 4 are Sangamo bin storage analog tape recorders and are used as a special buffering device. The read and playback capstans are driven independently, permitting different speeds and times of operation of the capstans. For approximately 40 minutes, incoming video data are recorded at 7.5 ips. The tape is deposited loosely in a storage bin and read into the processing computer in bursts at 30 ips. Therefore, the computer is free for uninterrupted processing for 3/4 of the total time between playback commands. Only one bin recorder is required operationally. The second provides backup.

c. Endless Loop Recorders—Sangamo tape recorders 5, 6, and 7 are of the continuous loop analog type. Recorders 5 and 6 are employed as buffers between the 7.5 ips transmission line data rate for AVCS picture data and the 60 ips rate required for operation of the kinescope picture reproduction system. The first recorder (TR 5) will record an odd numbered set of pictures in parallel while TR 6 plays back the preceding even numbered set of pictures serially with a speed-up of 8:1. Channel and recorder sequencing is under computer control. A

third recorder, TR #7, is continuously on the line and serves as a standby unit to back up TR #5 and #6. Gridding signals and special legend data may be recorded on the loop recorders in synchronism with the 7.5 ips video and time signal recording.

4.1.2.2 Analog Data Path

AVCS and HRIR signals are received operationally from the AT&T terminal equipment in an FM form. Timing signals are received synchronously with the data, but the HRIR and AVCS transmissions occur at different times. AVCS video and time data are routed through the tape loops described above to the RCA kinescopes and associated rapid film processors. In normal operations latitude-longitude grids will be computed and mixed with the video at the DAF station during transmission. If these grids are not available, grids will be generated and mixed with the video in the DAPAF. A basic gridding tape may be produced by the IBM 7094 from ephemeris, time and attitude data received before picture transmission. The CDC 160 A then adds the proper gridding signals to spare tracks on the tape loop as the pictures are recorded. Upon replay, these gridding signals cause the grid mixer to add grid points to the pictures displayed on the kinescope. HRIR video and time data are routed directly to the Westrex HRIR facsimile display for film recording.

The Ess Gee equipment operates in the same way for archiving as described above for operations except that TR 1 is used to replay tapes received by mail from the DAF stations.

4.1.2.3 Digital Data Path

HRIR data are recorded at TR #3 at 30 ips then played back at the same speed to the HRIR discriminator. The discriminator converts the FM signal to an analog voltage format. From the discriminator the data are fed to an analog-to-digital converter.

The AVCS video signals are recorded at 7.5 ips on TR 4. TR 4 plays back the FM video signal at 30 ips to the discriminator where it is analog-voltage formatted. The multiplexer sequences the information to the sampling rate of the analog-to-digital converter. The converter digitizes the analog video data.

The Format Control Unit (FCU) receives digitized AVCS video and HRIR information from the A/D converter. The AVCS video and HRIR data are formatted for acceptance by the digital computer data processing complex. The video information is transferred to the direct

data connection of the IBM 7094 under the control of FCU. The HRIR data is similarly transferred to the CDC 160 A.

The AVCS time signal (slow) is received from the AT&T terminal equipment at TR 1, 4, 5, and 6. At the same time, part of this signal is extracted and sent to the vertical sync detector where a negative pulse is produced for the grid signal switch. The AVCS time signal (real) is fed to an amplitude detector and pulse decoder where the amplitude modulated signal is demodulated and formatted for entry into the binary time code converter. This unit converts the AVCS real-time and half real-time and HRIR time data to a form usable by the FCU. The FCU makes the data available to the processing computers, IBM 7094 and CDC 160 A, as required.

The HRIR time data are received from the AT&T terminal and recorded on TR 3 at 30 ips. The signal follows the same path as the AVCS real-time to the amplitude detector and pulse decorder, then the binary time code converter and, finally, to the FCU.

4.1.2.4 Control Console

The console provides a means for manually controlling the system sequence of operation, and provides a visual indication of system operating status. The console will serve as a trouble shooting aid.

Two modes of program control are possible:

a. The automatic mode allows the computer program and the control logic to control the system.
b. The manual mode allows the controller to command all the individual operations and states of the system. Ingestion of data to the computers is by the automatic mode only.

4.1.3 COMPUTERS AND PERIPHERAL EQUIPMENT

The basic computer used in the NWSC operation is the IBM 7094. The CDC 160 A and IBM 1401 are used for specialized tasks in the system. Other peripheral equipment in the DAPAF includes link digital and analog display system, United Aircraft Company (UAC) encoder and transmitter, and an Electronic Associates (EA) data plotter.

In its prime operational mode, the IBM 7094 will utilize telemetry data, orbital elements, and digitized video data to produce a rectified mosaic or data summary in map form upon magnetic tape. These maps will express percent cloud, average brightness, and the pattern of picture

elements within a grid square. In addition, the 7094 is the major tool for most other operations and investigations in the DAPAF.

The CDC 160 A has two primary operational functions: gridding AVCS pictures and HRIR processing. The CDC 160 A forms on HRIR tape which is combined with telemetry data and timing information to form a final meteorological radiation tape (FMRT). Using the FMRT as an input, the IBM 7094 will produce rectified map scale HRIR data summaries.

The IBM 1401 computer is used as an output device. It converts IBM 7094 tape output into a computer printouts such as digitally rectified map scale mosaics of satellite television and infrared pictures.

The EA data plotter will not be used in the presently constituted normal mode. However, it may be used to produce a line drawn rectified gridded digital map representing clear, scatter, broken, and overcast areas of cloud cover.

The Link display equipment and the UAC encoder and transmitter are used to prepare the processed data for facsimile transmission or for local display. The function of this equipment will depend upon the mode of operation.

4.1.4 KINESCOPES AND PROCESSORS
There are three RCA kinescope assemblies. Two are combined with 70-mm cameras and rapid film processors for operational picture production. The third is set aside for production of 35-mm archival film and has no processor.

4.1.5 OUTGOING COMMUNICATIONS
The rectified gridded digital mosaic maps and kinescope produced gridded video photographs will be transmitted over 3-kc facsimile circuits. The photographs will be transmitted by Westrex photofacsmile equipment. Westrex or equivalent equipment is necessary for receipt of these pictures by the meteorological users.

Alden facsimile equipment will be used to transmit manual and digital derived nephanalyses over the following circuits:

a. Hi-altitude (10200)
b. International (10204 and 10205)
c. National Weather Facsimile Network

This information will be hand-carried to Air Force and Navy facilities for transmission on circuits: (1) USAF 1R9, (2) Navy Facsimile Circuit - Fleet Weather Control (FWC), Suitland.

The hi-altitude circuit will be used to transmit data to Navy FWC, Alameda, Calif., for further transmission.

Teletype bulletins of meteorological satellite data will be routinely prepared by the manual analysis team. These bulletins will be transmitted over the following circuits:

a. Northern Hemisphere Exchange Network
b. 205 (Lages Island)
c. 233 (Mexico City)
d. 235 (Albrook and South America)
e. Greenland-Canada

Special circuits will be utilized as available and needed. These include:

a. Project Mercury Facisimile Circuit to Miami. Westrex and Alden facsimile equipment capability.
b. Army Support. Suitland to Ft. Monmouth, New Jersey. Westrex and Alden facsimile equipment capability.
c. NASA circuits for special teletype bulletins of unusual and important meteorological occurrences. These circuits include:

- Baker-Nunn
- STADAN
- SCAMA Voice Circuits

4.2 PHOTOGRAPHIC LABORATORY

The Photographic Laboratory is equipped with specialized equipment for high-speed, high-quality film processing and copying. The photolab will provide film and print copies required in the operational and analysis function of DAPAF and the research requirement of the Meteorological Satellite Laboratory (MSL). The photolab has the primary responsibility for preparing meteorological satellite data archives.

The lab facilities to meet these requirements include the standard photographic reproduction equipment of enlargers, dryers, and

processors plus the special purpose units listed below. For quality control the photolab has a densitometer, a sensitometer, and a pH meter.

4.2.1 LOGETRONIC CONTINUOUS STRIP CONTACT PRINTER

This unit prints from a roll of either positive or negative transparency onto any roll of film or paper base. The unit features automatic control of the degree of dodging and exposure applied to the material being printed. This technique compensates for non-uniformity in the transparency and ensures uniform exposure from frame to frame and within each frame for a given printing material.

4.2.2 OXBERRY OPTICAL PRINTER

This printer designed for NWSC includes a Log Etronic VH 90 exposing light service which is flexible enough to meet the following NWSC requirements:

- 35-mm 1:1 roll-to-roll reproduction
- Negative-to-positive and positive-to-negative capability
- Unitized Record - 35-mm roll to 8 1/2-by-11 record sheet
- 35-mm to 5-by-7 paper prints in roll form
- 35-mm to 9-by-9 pictures in roll form

4.2.3 HOUSTON-FEARLESS SUPPER LAB FILM PROCESSOR

This unit can process negatives or positives in sizes of 16-mm, 35-mm, or 70-mm. It incorporates a complete chemical storage and replenishment system.

PART VIII

GSFC PLAN FOR THE HRIR EXPERIMENT

1. DATA PLAN

Data from the HRIR experiment will be conditioned in the following manner for analysis and interpretation within the Physics Branch of the Aeronomy and Meteorology Division.

The raw spacecraft HRIR analog information will be demodulated and then converted to an 8-bit digital format. This information, along with the decoded spacecraft and ground station time codes, will then be assembled into a buffer register for arrangement into the proper word structure for entry into one of the CDC 924 computers. The CDC 924 will process the data, check it for errors, arrange it into the required IBM format, and write it out onto a magnetic tape. This digital tape will then be ready for use in the IBM 7094. The output tape from the 7094 is the final meteorological radiation tape (FMRT), and contains the spacecraft position attitude errors, calibrated sensor data, geographical coordinates, and HRIR subsystem telemetry data. The FMRT will be considered the final and complete, reduced data repository resulting from the HRIR experiment. It is estimated that each orbit will require one 2400-foot reel of magnetic tape.

It is expected that after proper validation by HRIR Experimenter, these data will be distributed to the scientific community by the Aeronomy and Meteorology Division. If the HRIR experiment performs as expected, the HRIR information, after proper validation, can also be applied to operational meteorological use.

The analog-to-digital data processor hardware will be developed by the Data Systems Division. The Data Systems Division will also provide the following:

- Instruction, operation and routine maintenance manuals
- Any necessary instructions to the designated operators
- Consultants/advisors for any maintenance beyond routine servicing

The Data Systems Division will be responsible for the system until it is operational and accepted by the Nimbus project; the Nimbus NDHS Manager will provide the personnel to operate the data processor.

The hardware will have the capability of sampling the HRIR data at rates of 2000, 4000, 8000, and 16,000 times per second of playback time, or 250, 500, 1000, and 2000 samples per second of vehicle time. The hardware system will also be capable of providing a visible record of selected data containing both HRIR data and the associated time code. This method of processing the raw data as outlined makes use of one CDC 924 computer and certain other equipment which is available at NDHS.

The necessary computer programs and analysis on the 7094 will be provided by the Aeronomy and Meteorology Division, Physics Branch.

2. REAL-TIME PLANS

The basic purpose of real-time application of the HRIR experiment is to provide nighttime cloud-cover mapping only (i.e., map presentations of relative radiation intensities). The raw data will be released for operational meteorological analysis after proper validation of the experimental results. A partial validation will be accomplished as expeditiously as possible with the provision that any favorable results in the form of cloud pattern maps will be identified as "tentative" until a complete validation is made.

The immediate postlaunch phase of validating the HRIR data will depend largely upon examining the radiation patterns as shown on the Westrex photofacsimile recorder (gridded analog presentation). These data will be compared with nephanalyses from conventional meteorological observations, and with AVCS pictures taken in the same geographical area 12 hours previously. Radiation level patterns appearing on the 70-mm film will be checked against the nephanalyses and AVCS pictures and against surface-temperature patterns in cloud-free areas. Absolute measurements will not be attempted in the first phase of the program. Instead, relative radiation intensities as measured by distinguishably different gray levels on the filmstrip or different digits in the digital printout.

The Physics Branch will also examine the radiation data to determine if the radiometer is able to respond to various radiation signals levels, and if the output equipment (analog or digital) is able to depict them in

appropriate shades of gray. In essence, it will be necessary to know how well the radiometer can distinguish between high and low clouds and between cloudy and clear areas. A quick qualitative check will first be made by scanning the video intensitites, noting the number of gray levels discernible and the degree of contrast between adjacent areas.

The immediate postlaunch data program as discussed will require the assistance of one or more meteorologists from NWSC who will provide the GSFC Experimenter with conventional weather data as described in Part VII.

3. RESEARCH INVESTIGATIONS

Further and continued use of the data, utilizing both the digital and analog presentations, whichever is more appropriate in each specific instance, will be accomplished within the Physics Branch. The initial studies of the data will be concentrated on the following four areas:

- The ability of the radiometer to map cloud patterns and track storm systems will be investigated. Correlations with conventional data and with AVCS pictures will be pursued in detail.

- The ability of the radiometer to measure ground surface temperature and, by extension, to infer cloud top heights, will be investigated. Corrections for atmospheric absorption will be determined theoretically and empirically, and procedures for applying such corrections will be developed.

- The limb effect of the atmosphere on the radiance measured within this spectral region (3.8-microns to 4.2-microns) will be investigated.

- Special checks will also be made to determine the minimum temperature (maximum cloud height) at which the radiometer is able to separate low radiation signal levels from background noise.

The Physics Branch will also conduct a continuing program of such data content determinations throughout the spacecraft's lifetime to check the stability of the radiometer's calibration data while in orbit, and to discover any influence of prolonged space environment exposure on the characteristics of the detector cell, cooling cone, scanning mirror, and interference filter which will affect the overall performance

of the HRIR subsystem. Additional areas of study may be delineated depending upon the outcome of the initial evaluation.

APPENDIX A

DETAILED DESCRIPTIONS OF LAUNCH VEHICLE AND SPACECRAFT, VAN GROUND STATIONS, AND LIST OF AGE

1. LAUNCH VEHICLE

Nimbus A will be launched by a Thor-Agena-B vehicle (Figure A-6).

1.1 THOR

The Thor is manufactured by Douglas Aircraft Company (DAC) under contract for the Air Force Space Systems Division (AFSSD). Douglas Model DM 21, Mod. II, will be used in modified form for the Nimbus A flight. The Thor booster is powered by a Rocketdyne engine. The propellants are liquid oxygen and RJ-1. For final adjustment and roll control, two smaller Rocketdyne vernier engines are used.

Guidance will be by means of Bell Telephone Laboratories (BTL) guidance systems, series 400. Booster requirements are further described in DAC specification DS-2110, Performance Specification for Space Research First-Stage Vehicle, Douglas Model DM-21.

1.2 AGENA-B

The second-stage Agena-B was developed and is produced by the Lockheed Missiles and Space Company (LMSC), Sunnyvale, Calif.

The Agena-B is approximately 20.5 feet long by 5 feet in diameter without payload and booster. The forward equipment rack contains the electronic and guidance equipment, including the battery, horizon sensor, velocity meter, and inertial-reference package. The center section of the vehicle contains the fuel and oxidizer tanks; the aft contains the rocket engine, vehicle control equipment, and interface attachments for the booster.

The Agena-B is attached to the booster by an adapter which encloses the aft section of the Agena-B vehicle. The adapter stays with the booster upon separation and contains the booster retrorockets and the Agena destruct system. The adapter is detached by explosive boltcutters.

1.2.1 PROPULSION

The liquid propulsion engine uses unsymmetrical dimethyl-hydrazine (UDMH) as fuel and inhibited red fuming nitric acid (IRFNA) as the oxidizer. The engine, a Bell type 8096 with a hydraulically controlled swiveling arrangement, generates a thrust of approximately 16,000 pounds with a burning time of about 240 seconds in one continuous firing or two separate firings. The fuel system is pressurized from a 3600-psi helium source tank through a pressure-regulating system. Two pairs of ullage rockets give the vehicle the necessary acceleration to collect the oxidizer and fuel at the pump inlets before each ignition.

1.2.2 GUIDANCE AND CONTROL

The vehicle guidance system consists of four basic components: inertial-reference package, velocity meter, horizon sensor, and sequence timer.

The inertial-reference package consists of three body-mounted gyros which sense motion in the pitch, roll, and yaw axes of the Agena. Preamplifiers, power amplifiers, and associated circuitry complete the package which furnishes displacement signals to the flight-control system.

The velocity meter consists of an accelerometer which produces pulses proportional to the acceleration, and a digital counter which integrates these pulses and initiates engine cutoff when the vehicle has attained the programmed velocity.

The horizon sensor detects the horizon of the earth by the difference in heat signal between the earth and surrounding space. An error signal is then generated, fed into a mixer box, and converted to torque signals to the gyros furnishing pitch and roll correction to the guidance system. The sequence timer, started at liftoff, programs the sequence of events of the Agena flight phase including engine start and spacecraft separation.

1.2.3 AUXILIARY POWER SYSTEM

During powered flight, the vehicle is controlled in pitch and yaw by a hydraulic servosystem which gimbals the main engine. Roll attitude is controlled by gas jets. In the coast phase, yaw, pitch, and roll are controlled by the gas jets.

1.2.4 COMMUNICATIONS AND TRACKING

The communications subsystem monitors functional and environmental conditions in the Agena and the payload section, and telemeters this information to ground monitoring stations through the VHF FM/FM unitized telemetry equipment. A C-band beacon transponder which transmits a radar beacon in response to radar interrogation is used for tracking purposes.

1.2.5 DESTRUCT SYSTEM

The destruct system for the Agena is a shaped charge which fires directly into and ruptures the propellant and oxidizer tanks. The actual destruct mechanism, mounted on the booster-Agena adapter, stays with the booster upon separation. The destruct mechanism is fired by a discrete signal from the booster, initiated either by a malfunction such as improper separation, or by a ground-initiated signal. No provision is made for destruct of the Agena after separation.

1.3 SPACECRAFT-AGENA INTERFACE

The interface between the spacecraft adapter and the spacecraft will consist of an explosive boltcutter-actuated V-band separation clamp that forms the transition from the spacecraft to the 60-inch-diameter Agena forward midbody (Figure A-1). Upon actuation of the separation-system V-clamp, compression springs will impart a separation velocity of approximately 4 feet per second to the spacecraft.

1.4 REFERENCE AXES

The Agena will support the spacecraft with reference positions and separation points as shown in Figure A-2. The spacecraft and vehicle geometric axes will be aligned to within 1 degree. Four sets of axes define the spacecraft:

- The orbit axes, defined by the earth's local vertical and the velocity vector
- The body axes, defined by the position of the scanners and inertial sensors used for axis orientation
- Principal moment axes, defined by the principal moment-of-inertia axes of the assembled spacecraft
- Geometric axes, defined by the alignment reference in the spacecraft

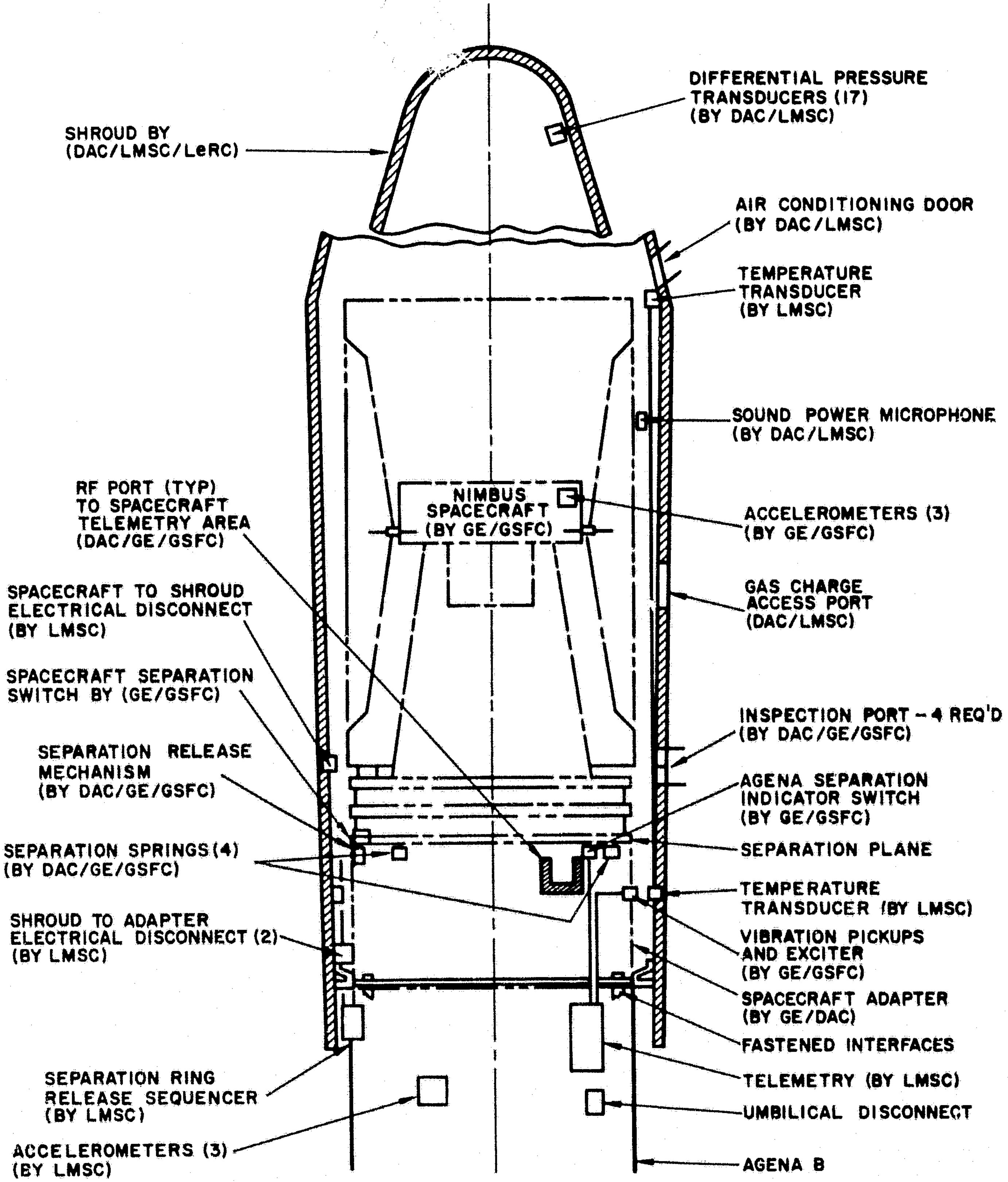


Figure A-1 – Spacecraft-Agena Interface

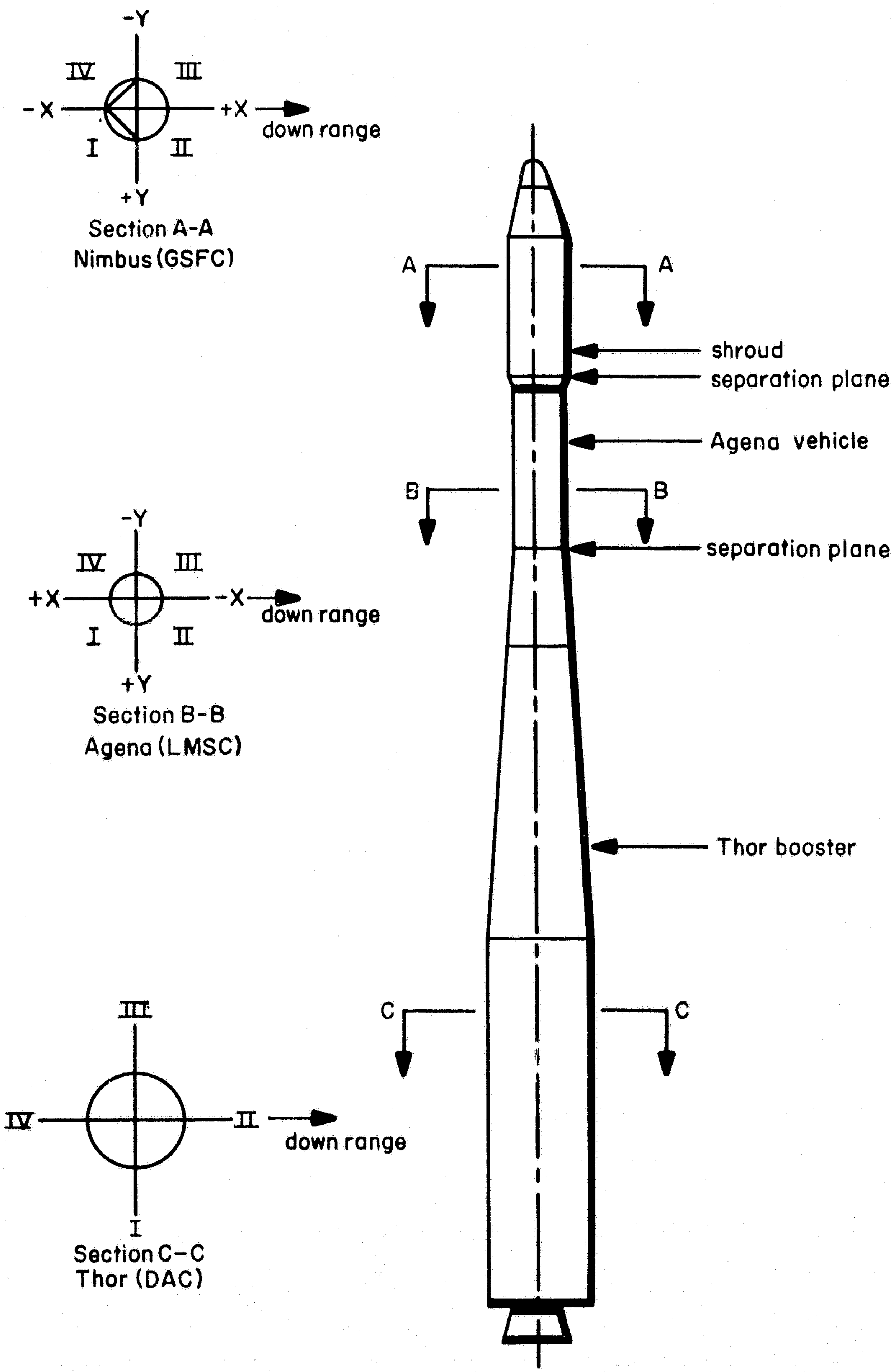


Figure A-2 – Thor-Agena-B-Nimbus Coordinate Axis System

The orbit-axes system is a set of three axes at the center of mass of the satellite, rotating in space so that one axis (coinciding with the earth's local vertical) is positive downward; the second axis (orthogonal to the first) lies in the instantaneous orbital plane with the positive sense in the direction of the velocity; the third axis (orthogonal to both the local vertical and the instantaneous orbital plane) is positive to the right when looking in the direction of the velocity vector.

The body axes are defined by the sensory elements of the control system. They consist of a set of three orthogonal axes having the same sense and center as the orbit-axes system, but fixed in the vehicle. The earth-pointing axis is referred to as the yaw axis; the instantaneous orbital-plane axis as the roll axis; and the third axis as the pitch axis.

The principal moment axes are a set of three axes centered at the center of mass of the spacecraft so that one axis coincides with the principal moment-of-inertia axis nearest the body yaw axis. The second and third axes coincide with the principal moment-of-inertia axes nearest the roll and the pitch body axes, respectively.

The geometric axes are defined by the layout of the spacecraft. The general location of these axes is defined by a line perpendicular to and centered on the separation ring, a line parallel to the solar panel shaft center, and a line perpendicular to the plane defined by the above lines. Specific locations of the geometric axes are defined by an index placed on the base at the time of assembly and referenced to a jig supporting the spacecraft during assembly.

1.5 THOR FLIGHT PHASE

Upon launch the vehicle rises vertically for about the first 10 seconds, during which time the vehicle is rolled as required to give it the proper azimuth. For about the first 100 seconds of flight the vehicle is maintained on the programmed trajectory by auto-pilot; at the end of this period the BTL guidance system takes control of the vehicle.

The propellant utilization system will initiate shutdown upon indications of depletion of one of the propellants. The BTL ground RF link will then set the timer in the second stage to assure that the Agena will provide the velocity gain required to achieve the desired orbit. The powered phase of the flight lasts approximately 156 seconds from launch; from this point, the vehicle continues on its flight under control of the vernier engines which position the vehicle according to continued

signals received from the guidance system. When the correct attitude is achieved, the guidance system generates a signal to cut off the vernier engines.

1.6 AGENA FLIGHT PHASE

1.6.1 BOOSTER SEPARATION

Separation of the Agena from the first-stage Thor begins with the actuation of the separation system and booster retrorocket firing. Separation is accomplished when the Agena is in free independent flight. The separation sequence is controlled by a programmer in the Agena; operation of the programmer is initiated by command signal from the booster guidance.

1.6.2 AGENA FIRST BURN AND TRANSFER ELLIPSE

At the conclusion of the postseparation coast phase, two ullage rockets on the Agena will be ignited to provide an impulse sufficient to place the propellants at the propellant pump inlets. Simultaneously, the velocity meter is armed for integrating the velocity gained by the Agena during the first-burn period, to determine the engine cutoff point. The hydraulic pitch and yaw attitude controls are activated to position the thrust angle of the engine during operation. The engine is ignited to provide the impulse needed to place the Agena-spacecraft combination in a transfer ellipse. The velocity meter causes engine cutoff when the required velocity is reached; the Agena-spacecraft combination then coasts to apogee of the transfer ellipse.

1.6.3 AGENA SECOND BURN

In preparation for the Agena second-burn operation, the remaining two ullage rockets are fired to place the propellants properly for engine ignition; the velocity meter is armed for integration and the engine is ignited. When the required orbital velocity increment is gained, the engine thrust is terminated.

1.6.4 AGENA PITCHUP AND SEPARATION

Following Agena second burn, the vehicle is stabilized by the Agena control system. The Agena horizon scanners are then turned off, and a pitchup maneuver of approximately 80 degrees at a rate of one degree per second is executed. Explosive boltcutters on the V-band separation clamp securing the spacecraft to the adapter are ignited 112 seconds after second burnout, and the spacecraft and Agena are separated. Calibrated separation springs provide a separation velocity of 4 feet

per second. The delay in separation eliminates the possibility of a thrust impulse arising from boiloff of residual propellants.

1.6.5 AGENA PITCHDOWN

After the spacecraft has been separated, the Agena is pitched down to the horizontal and remains on normal attitude control until control gas and battery power are exhausted. Detailed studies have shown that the Agena and spacecraft maintain satisfactory separation distance from each other; therefore, no forcible withdrawal of the Agena is required.

2. SPACECRAFT

The structural arrangement of the Nimbus spacecraft (Figure A-3) consists primarily of three sections: the upper or attitude control housing, the lower or sensory section, and an interconnecting truss structure.

The hexagonal upper section (Figure A-4) contains the solar-array and attitude-control subsystems, and provides unobstructed exposed mounting for the sun sensors, horizon scanners, control nozzles, and command antenna. The solar-array paddles attach to control shafts projecting from the control housing.

The control housing is attached to the lower housing by a truss structure consisting of six members knee-mounted in laterally adjustable sockets. The truss structure, attached to three points on both the upper and lower housings, provides the critical alignment required between the control system and sensor equipment. The lower housing is constructed in the form of a hollow circular section composed of 18 rectangular module pockets and V-shaped separators (Figure A-5). An H-frame structure attached to the inner wall of the circular ring provides accessible mounting for the advanced vidicon camera subsystem (AVCS), high-resolution infrared radiometer (HRIR) and AVCS recorders, and automatic picture-transmission (APT) camera and antenna. The modular pockets house the electronic equipment and battery packs. The lower surface of the ring provides mounting space for the HRIR and S-band antenna.

In the launch configuration the solar array is folded along its longitudinal axis and secured by a latch mechanism to the truss structure. The solar paddles are deployed and sun-oriented shortly after the spacecraft is in orbit.

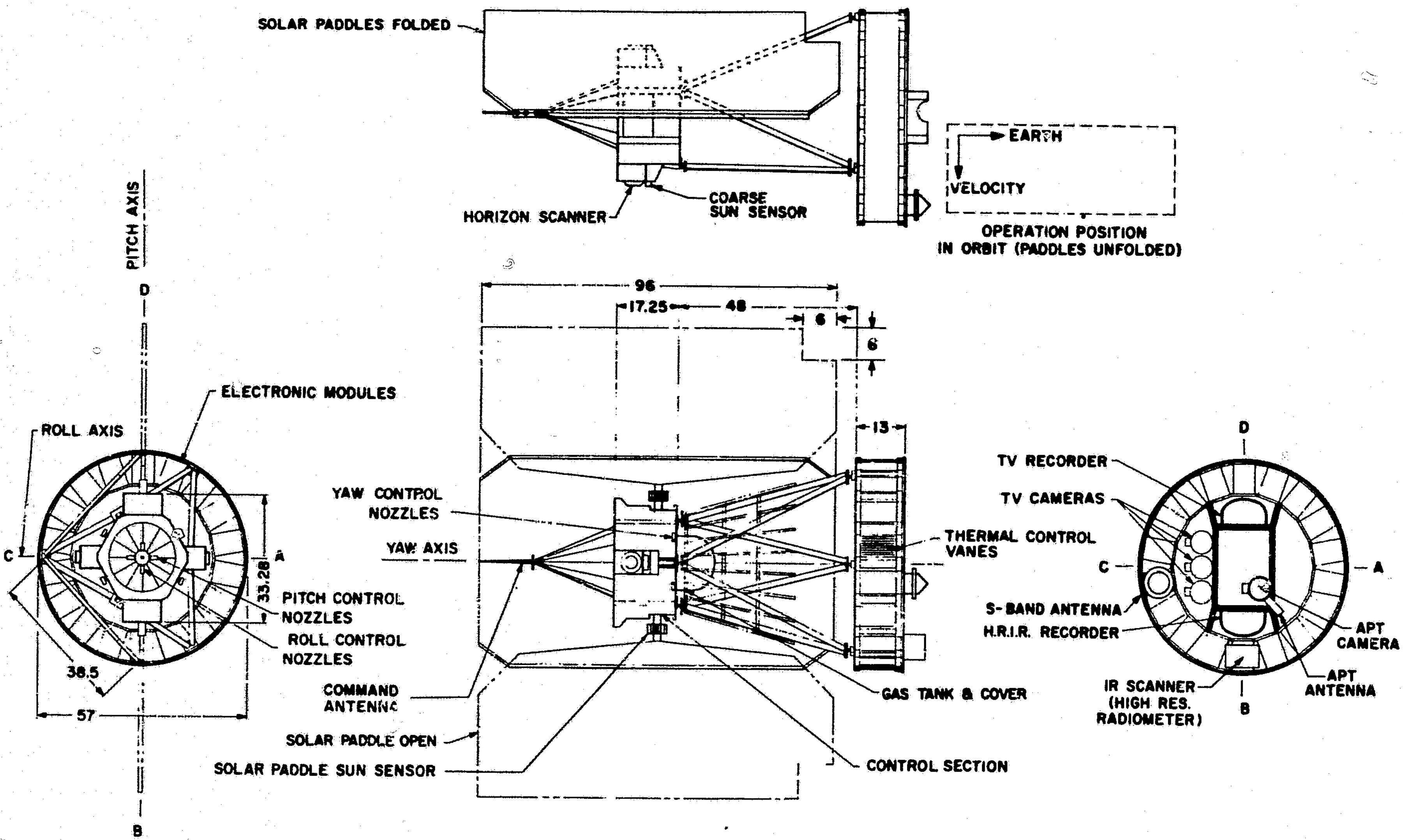
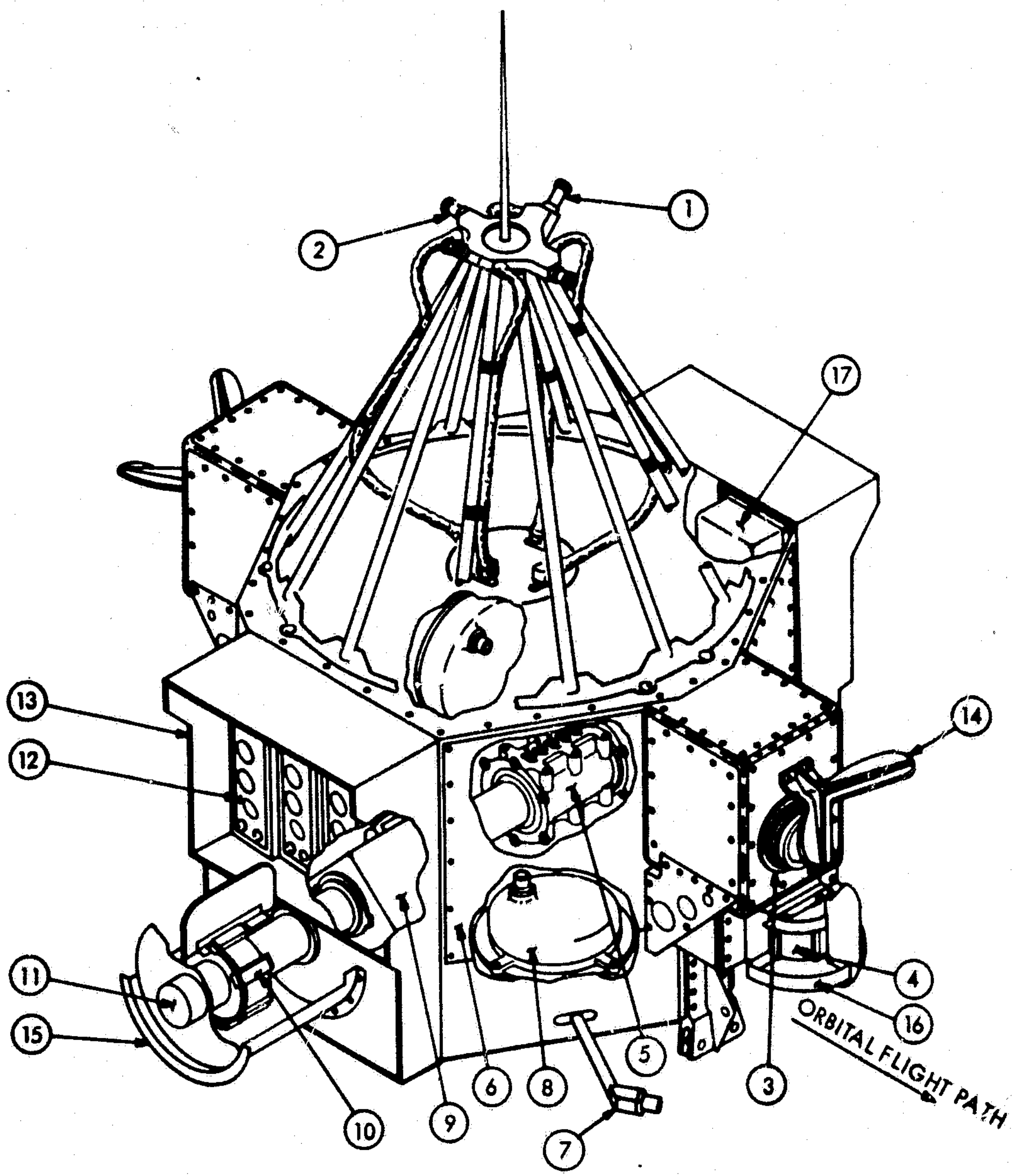


Figure A-3 – Nimbus General Arrangement Drawing



1 ROLL NOZZLES (2)
2 PITCH NOZZLES (2)
3 IR HORIZON SCANNERS (2)
4 COARSE SUN SENSORS (2)
5 SLIP RING ASSEMBLY
6 PANEL 1 (1 OF 6) CLOCKWISE LOOKING FORWARD
7 YAW NOZZLES (4)
8 FLYWHEELS (3)
9 SOLAR ARRAY DRIVE MECHANISM
10 SOLAR ARRAY SUN SENSORS (2)
11 SOLAR ARRAY SHAFT
12 SHUTTERS
13 TEMPERATURE CONTROLS (2)
14 IR SCANNER SUN SHADES (2)
15 SOLAR ARRAY SENSOR ALBEDO SHIELD
16 COARSE SUN SENSOR ALBEDO SHIELD
17 GYRO

Figure A-4 – Spacecraft Control Section

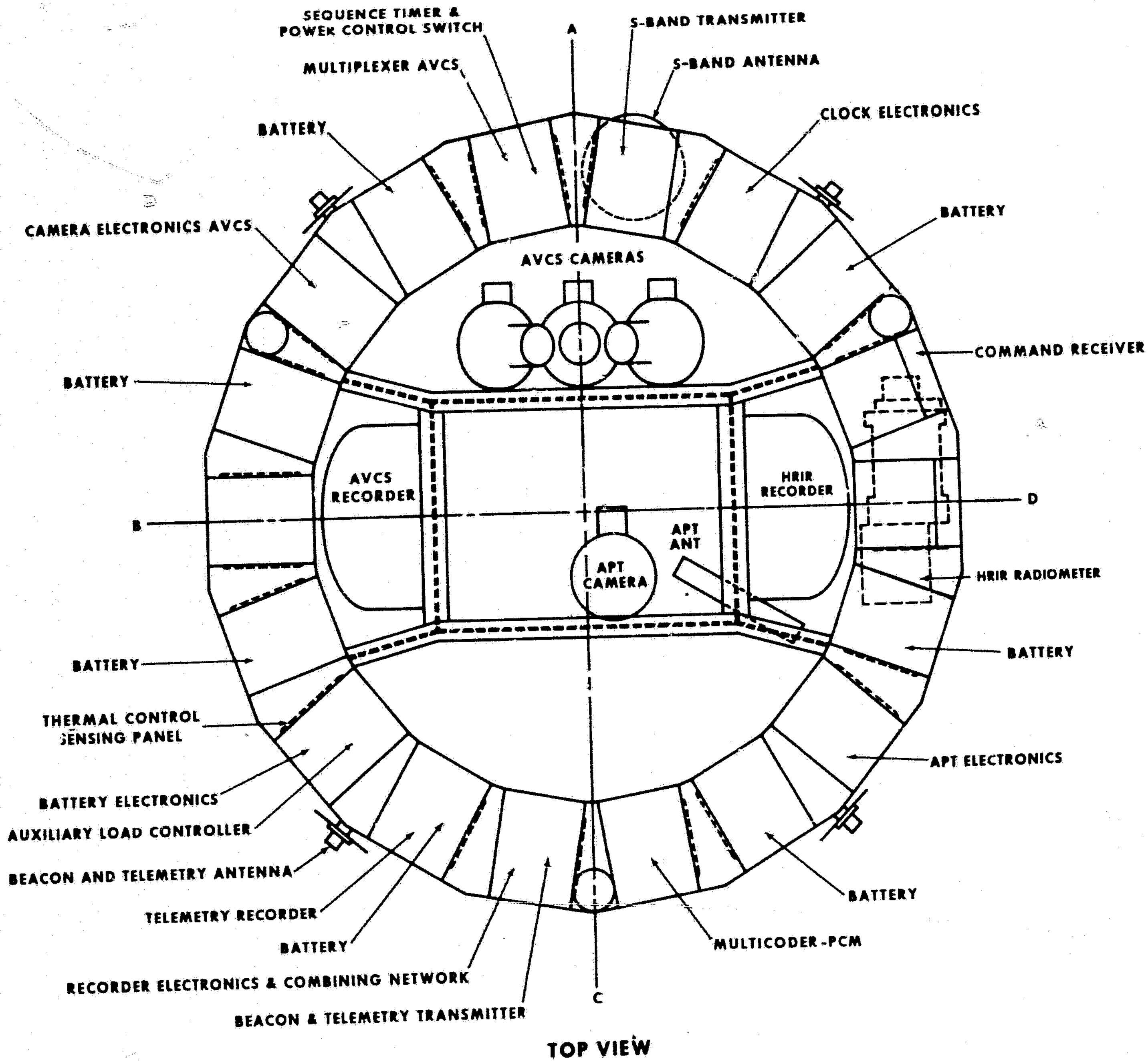


Figure A-5 – Sensory Ring, Top View

This configuration (when deployed and oriented) permits unobstructed viewing of the earth by AVCS and APT cameras, HRIR sensor equipment, and of the sun by the sun sensors and solar array. In addition, the geometry and mass distribution support the attitude control-subsystem action, permitting extended three-axis earth stabilization with a minimum of expended energy.

2.1 POWER SUPPLY

A single primary power supply delivering -24.5 volts regulated within ±2 percent has been developed to meet the requirements of the experiments and spacecraft subsystems (Figure A-6). Major components of the supply are an array of silicon solar cells mounted on two 3- by 8-foot solar-oriented paddles, nickel/cadmium storage batteries, and regulating and protective devices.

Initial power output is 450 watts during periods of full solar illumination, with 1.5 percent degradation each week after 100 days operation. In order to conserve power the spacecraft is programmed to turn off the subsystems when they are not in use. Average power output for all spacecraft requirements is 250 watts.

Power is obtained from conversion of solar energy by the silicon cells located on one side of two solar-oriented paddles. The cell requirement (10,982 cells, 2 cm by 2 cm) was established by considering the variation in load, due to experiment and spacecraft demands, during light and dark periods; the period of coincidence of illumination time versus interrogation time; and a statistical analysis of probable cell failure. The cells are connected in series-parallel arrangements, based on the probable-failure mode of the cells in conjunction with the voltage-current requirements of the spacecraft. The solar cells are arranged on one side of the honeycomb-constructed paddle (Figure A-7) which, in addition to providing structural integrity, offers excellent thermal conductivity between the two surfaces, thereby minimizing temperature gradients. The absorptivity/emissivity ratio of the front and rear surfaces was selected to maintain solar-cell temperature within a range where the cells are most efficient. (The solar cells are 11.9 percent efficient under tungsten illumination at 30°C, but have a negative temperature coefficient.) In addition, to lower the operating temperature of the cells, a red-blue filter is used to reject that portion of the spectrum to which the cells are insensitive. The expected average paddle-operating temperature is approximately 40°C, with extremes ranging from -80°C to 60°C.

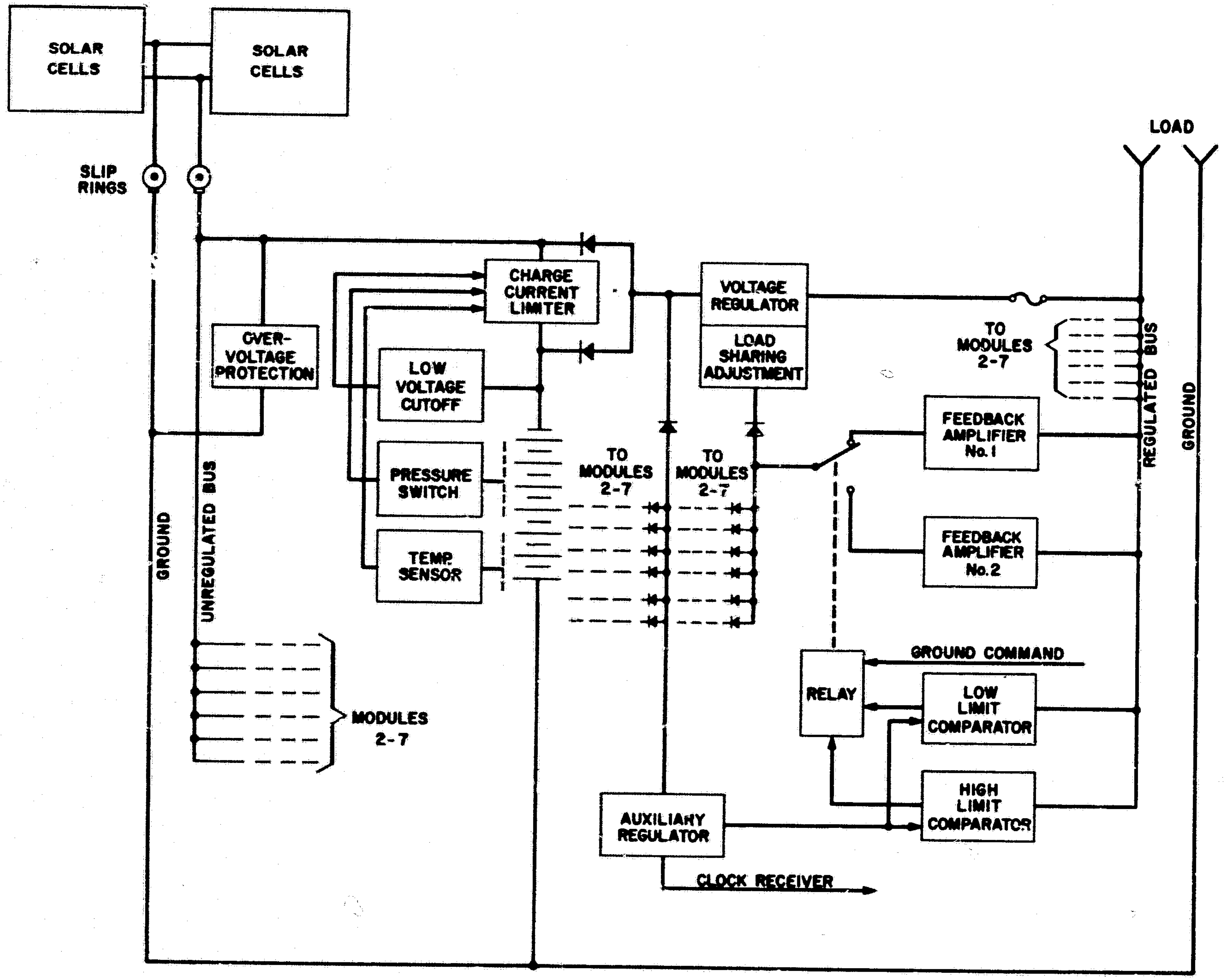


Figure A-6 – Spacecraft Power Supply, Block Diagram

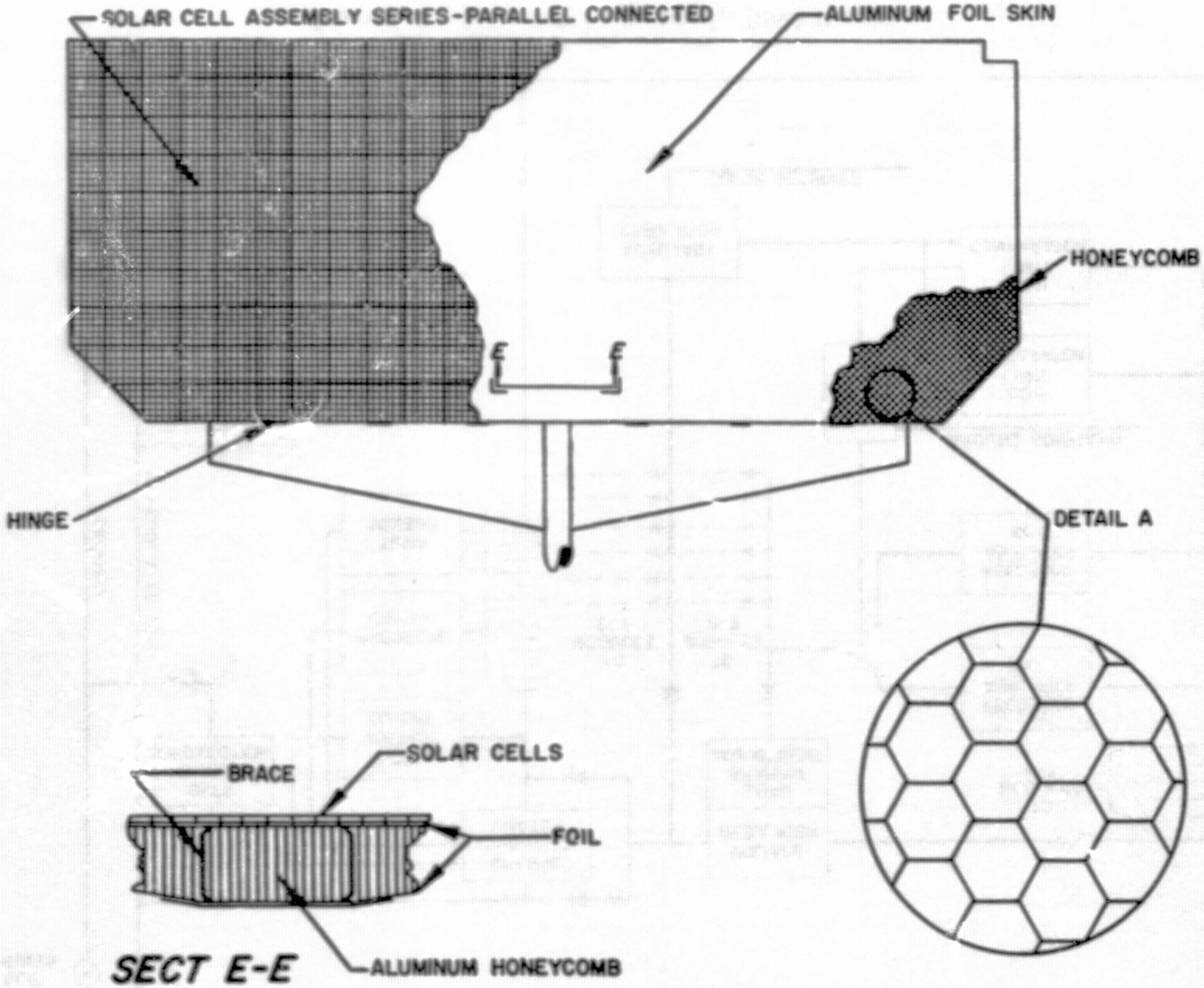


Figure A-7 – Solar Panel Construction

The storage batteries are packaged into seven parallel-connected modules, each consisting of 23 series-connected nickel/cadmium cells. Each cell has a 3.2-ampere-hour capacity with a minimum terminal voltage, at discharge, of 1.15 volts. To ensure system reliability, individual charge and discharge regulators are provided for each module; the charge regulators limit the sharing current to 1.5 amperes. The voltage regulators and a load-sharing balance arrangement maintain acceptable discharge rates for each battery.

Six of the seven battery modules are capable of satisfying the power demands of the spacecraft. Additional failures would require a proportionate reduction in load. Each module contains fuses and blocking diodes to prevent a short-circuited unit from discharing the remaining batteries.

Sensor elements and associated circuitry detect excessively low voltage, high temperature, and pressure conditions. When actuated, the sensor circuits reduce the charging current to a trickle rate. Battery-module operating temperature is maintained at approximately 25°C; however, component temperature within the module may reach 55°C.

2.2 CLOCK

If the meteorological information obtained by the sensor systems is to be of use, it has to be related to geography; to provide this relationship, absolute time determination is necessary. A crystal-stabilized oscillator performs this vital function. An 800-kc aged crystal, sealed in glass and maintained at a constant temperature by a heating coil, provides an accurate timing reference. This time can be reset whenever necessary.

Figure A-8 is a block diagram of the clock circuit, showing the frequency-division chain and pulse applications. Frequencies from 100 cps up are generated by counting down from the 800-kc oscillator output. Additional computer logic generates 10- and 1-cps squarewave signals. Both the 50- and 10-kc outputs are amplitude-modulated with the standard NASA time code; this code, which has a frame rate of 1 per second, uses four-bit binary-coded decimal for seconds, tens of seconds, minutes, tens of minutes, hours, tens of hours, days, tens of days, and hundreds of days. "Zeros" correspond to 2-millisecond pulses; "one" to 6-millisecond pulses. Appropriate sync pulses are interlaced, resulting in an average pulse rate of 100 cps. The code is generated by a small computer using a magnetostrictive delay line as the temporary storage element. Appropriate circuitry converts the

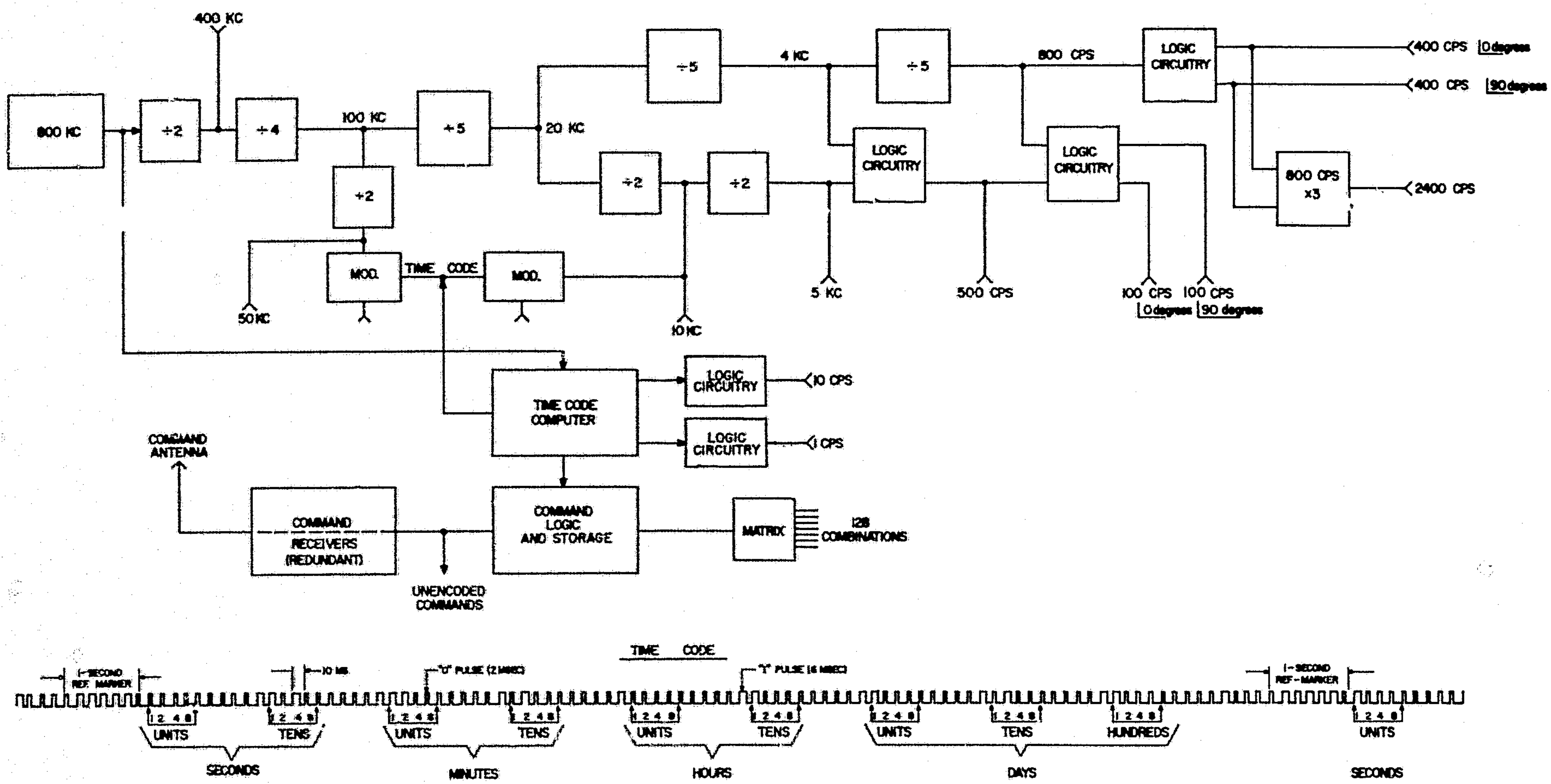


Figure A-8 – Spacecraft Clock Circuit, Block Diagram

time code in the delay-line storage element to the desired code format. The timing code then modulates the two coherent carriers, 50 and 10 kc. The 10-kc frequency alternates with the telemetry transmission on the tracking beacon.

The receivers, connected in parallel, with fail-safe isolation circuitry to implement redundancy, receive binary-coded signals and feed the command logic. A total of 128 different commands can be transmitted, and storage is provided for five unencoded commands. In case of clock failure, unencoded commands provide a minimum command backup such as the capability for obtaining telemetry information.

2.3 ATTITUDE CONTROL

Primary requirements of the attitude control subsystem are to orient and stabilize the spacecraft with respect to the earth and the orbit plane, and the solar paddles with respect to the sun. The attitude control subsystem uses two infrared horizon scanners, a coarse sun sensor, and a rate gyro as sensors. Three motor-driven flywheels and eight freon gas nozzles act as torque generators, to provide attitude control.

The spacecraft coordinate system (Figure A-9), defined by the location of the scanners and torquer devices used for axis orientation is, when the spacecraft is oriented:

- The yaw axis points toward the center of the earth
- The roll axis, perpendicular to the yaw axis, is parallel to the instantaneous orbital plane in the direction of the vehicle's velocity vector
- The pitch axis, perpendicular to both the yaw and roll axis, coincides with the solar-array axis

Major components of the attitude control subsystem are:

- Horizon scanners and associated equipment for pitch and roll control
- Yaw attitude-control loop including a rate gyro for maintaining the roll axis in the orbital plane
- Solar-array control loop

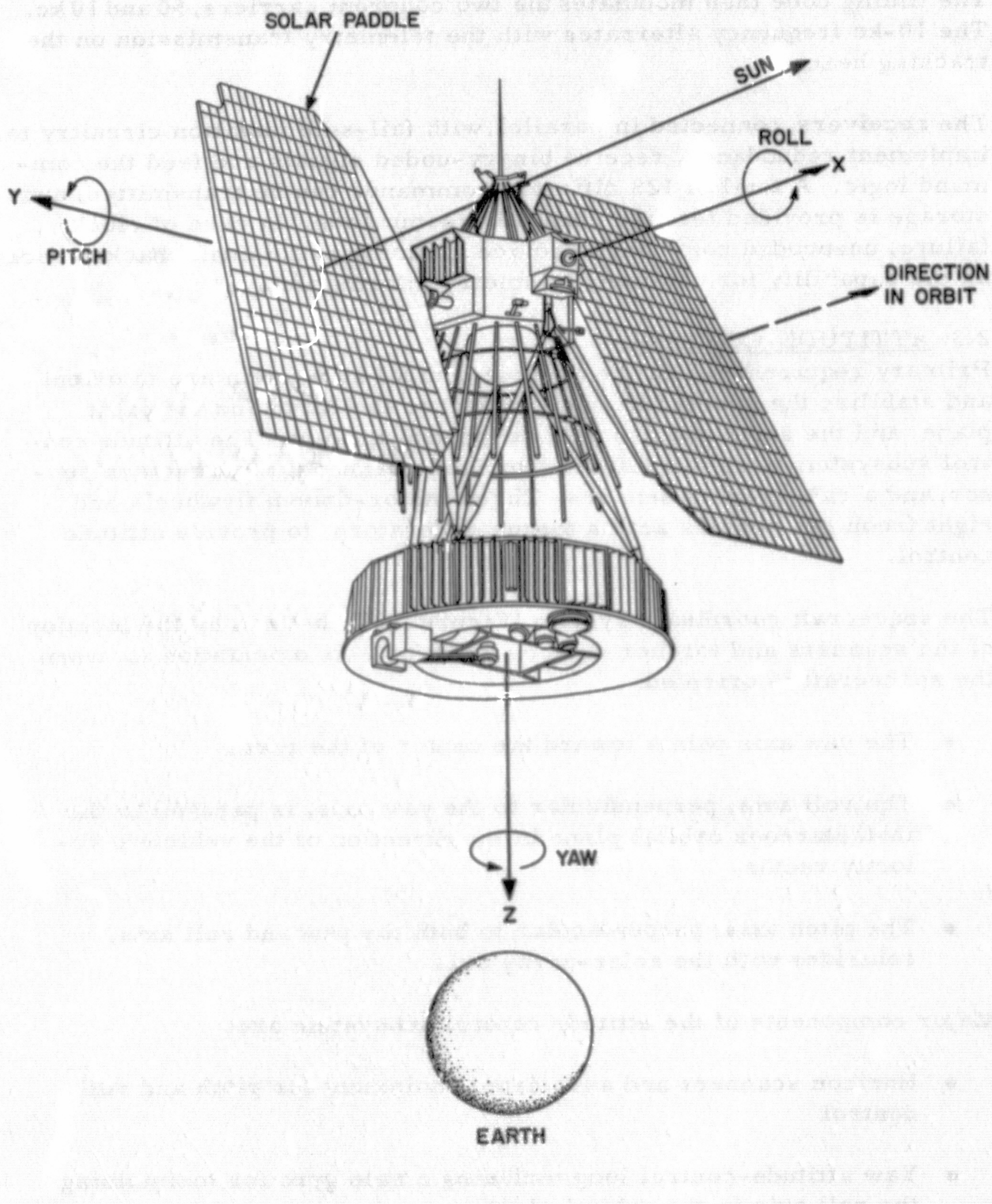


Figure A-9 -- Nimbus Coordinate System

- Programmer for timing and sequencing of automatic stabilization procedures and ground-command control operation

Auxiliary components such as telemetry conversion circuits, power regulatory supplies, freon gas subsystem (for storing and controlling gas flow), and means for thermal control complete the control package.

2.3.1 HORIZON SENSING

After separation from the Agena-B two infrared horizon scanners located on the roll axis are used to sense vehicle attitude with respect to the earth, for pitch and roll computation. The scanners, one looking forward and the other looking to the rear, generate a sky-earth signal which, when applied to the attitude computer logic circuits, produces both pitch and roll error signals which in turn operate the pitch and roll flywheels and nozzles to stabilize the spacecraft in pitch and roll.

2.3.2 YAW ATTITUDE DETERMINATION

Yaw error is detected by a yaw gyro in a rate mode aligned with its input axis in the vehicle roll-yaw plane (12 degrees toward negative yaw from positive roll). Thus aligned, the gyro senses orbital rate proportional to the sine of the angle between the vehicle roll axis and the vehicle velocity vector. This error signal is applied to the yaw reaction wheel to correct the yaw error.

Yaw attitude adjustment is also possible by ground command. This consists of a correction voltage added to the gyro output to compensate for zero shift and to maintain the solar array perpendicular to the sun under poor orbit conditions.

2.3.3 TORQUE GENERATORS

Operation of the pitch, roll, and yaw torque generators differs primarily in application and method of control. The functional operation of the torque generators in stabilization and control is as follows: during initial stabilization, momentum is removed from the vehicle by expelling gas from the control nozzles until the large initial vehicle rates and orientation errors are reduced to small values which can be handled by the flywheels. The flywheels then absorb small and cyclic disturbances by storing and returning momentum to the vehicle. Sensor error signal is amplified and converted, by the reaction wheel amplifier, to provide control-phase voltage to the momentum-generator motor. The momentum generator flywheel consists of a reaction wheel, designed as an integral part of the rotor of a two-phase servomotor (rotor and stator positions inverted). Acceleration of the reaction wheel produces a countertorque on the vehicle body. A digital tachometer monitors the speed and rotation of the reaction wheel, triggering gas-nozzle

operation when the wheel speed nears saturation. When triggered by the tachometer circuit, the gas-nozzle system provides a momentum pulse of the required polarity and duration to unload the reaction wheel. This is accomplished by energizing the gas-system solenoid valve, which allows gas to escape through the appropriate nozzles to produce error-compensating torque pulses of one-half-second duration.

2.3.4 SOLAR ARRAY ORIENTATION

The solar array, with a single degree of freedom about an axis parallel to the vehicle's pitch axis, is oriented toward the sun by a sun-sensor assembly located on each of the paddle shafts. The sensor output is zero (null) when the paddles are perpendicular to the sun. Sensor output (reflecting orientation error) is amplified and converted for use as the control phase voltage, to drive the paddle servomotor. Sun alignment is maintained within a few degrees of the earth-sun line for most of the daylight portion of the orbit.

A potentiometer, geared to the paddle control shaft, provides paddle position. Feedback from the potentiometer is summed with the sun-sensor signal, and in the absence of the sun signal (night phase) causes the paddle to be driven (at five times normal rate) to the potentiometer null position. Potentiometer null corresponds with paddle sunrise-acquisition position.

2.3.5 PROGRAMMER

The programmer provides timing, sequencing, and switching control signals and control voltages for logical governing of the attitude control subsystem. Major functions are:

- Initial stabilization
- Yaw control switching
- Yaw gas system control
- Fine correction commands
- Yaw bias commands

Spacecraft separation from the Agena occurs at an attitude of 10 ± 5 degrees from the vertical, following an Agena pitchup maneuver for initial orientation. Separation actuates a switch that starts a 2.5-second timer and removes the relay holding voltage (used to maintain

all relays in the reset state during launch). Next, at 2.5 seconds, a pyrotechnic signal cuts the cable holding the paddles in latched position and starts the paddle-unfold motors which open the paddles. Eight and one-half seconds after start of the paddle drive, when the rear horizon scanner is cleared, the programmer actuates the pitch and roll control loops and starts the yaw control timer. Yaw stabilization using the gyro is initiated 40 seconds after enabling the pitch and roll loops. Yaw stabilization and the solar array drive proceed concurrently to face the paddles toward the sun.

2.3.6 GAS SUBSYSTEM

Figure A-10 is a block diagram of the gas subsystem, which is designed to produce an angular acceleration (torque/moment-of-inertia ratio) of approximately $0.1°/sec^2$ in either direction around all three axes.

Torque about the yaw axis is provided by two pairs of nozzles located on opposite faces of the control housing; torque about the pitch and roll axes is derived from pairs of opposing nozzles located symmetrically about the yaw axis on the top of the ground plane portion of the command antenna. In each case, an accelerating moment is available in either the positive or negative direction about each axis.

The freon actuating gas is contained in a titanium storage tank attached, by strap fasteners, in a well at the bottom of the control housing. The initial gas charge is 6.5 pounds of freon compressed to 1250 psig at 68°F (20°C).

The gas tank has been proof-tested to pressures in excess of 5000 psi. A thermistor and high-pressure transducer serve to monitor tank temperature and pressure for telemetry purposes. Gas flow to individual nozzles is controlled by solenoid valves actuated by signals from the various attitude-control loops.

2.4 SPACECRAFT TRANSMITTERS

Spacecraft transmitting capabilities (Figure A-11) are provided by radio links consisting of:

- Tracking and telemetry (136.5 Mc)
- S-band, AVCS and HRIR (1707.5 Mc)
- APT (136.95 Mc)

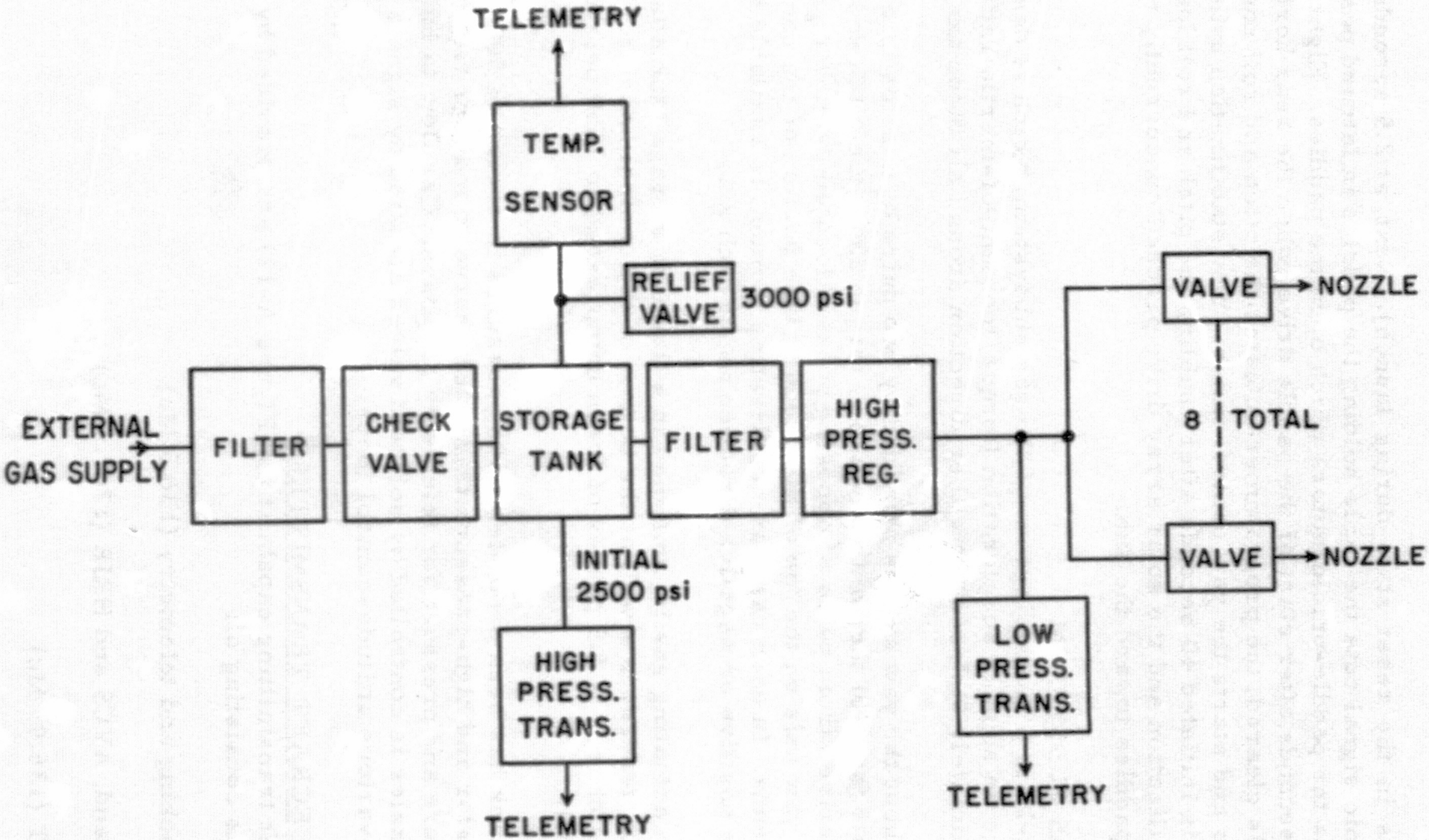


Figure A-10 – Gas Subsystem, Block Diagram

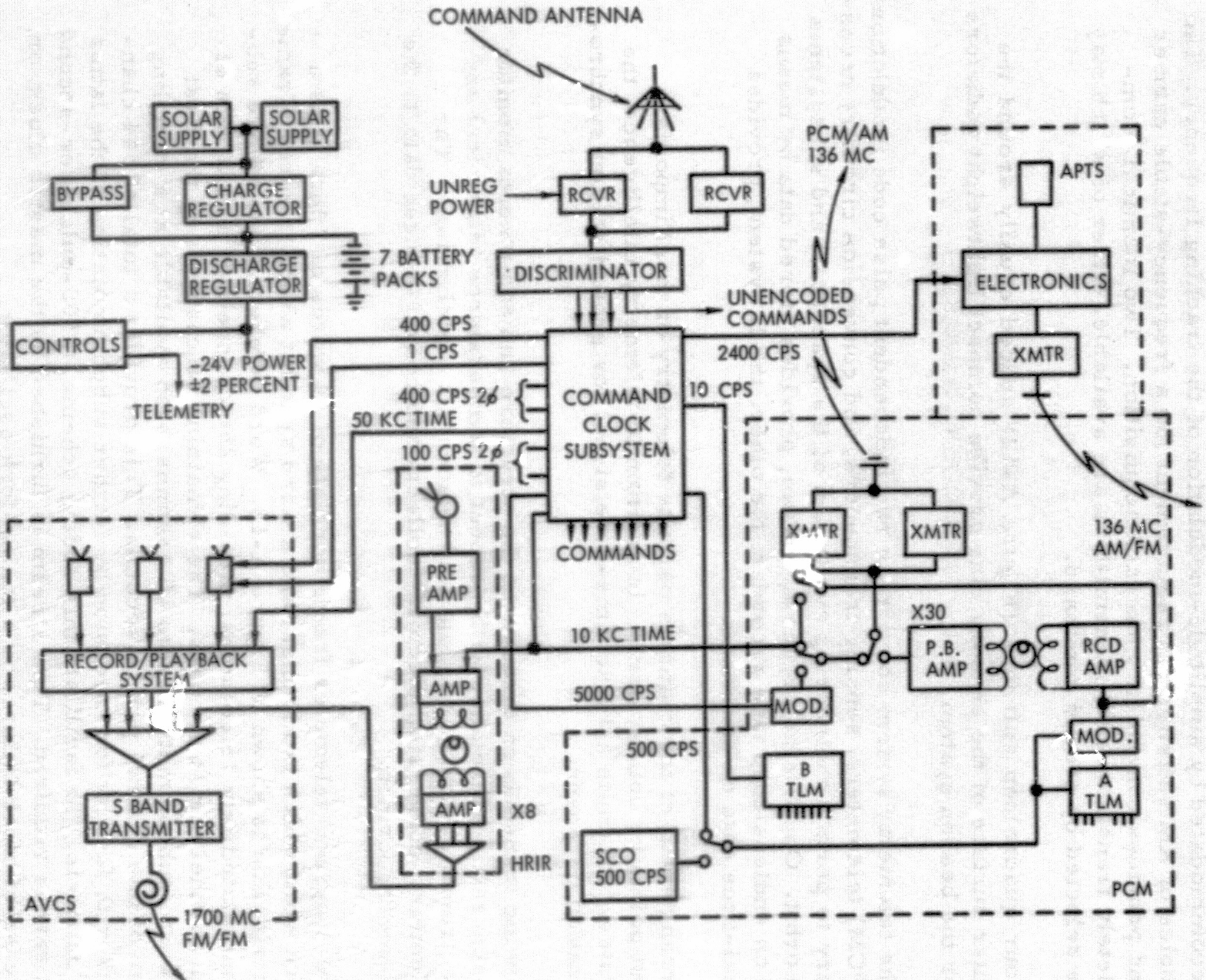


Figure A-11 – Communications System, Block Diagram

2.4.1 TRACKING AND AM TELEMETRY

The 136.5-Mc 0.35-watt tracking beacon and telemetry transmitters enable the STADAN network to track the spacecraft. Telemetry is accommodated by amplitude-modulation of the tracking frequency. The choice of AM satisfies the requirement for a frequency-stable carrier and provides convenient autotrack acquisition. Two identical (completely transistorized) transmitters are available, either of which may be selected by ground command.

Four quadraloop antennas (Figure A-12) spaced equally around the outer surface of the sensory ring provide compact lightweight radiators for the beacon system.

The telemetry system consists of two independent pulse code modulation (PCM) telemeters, sensing transducers, and conversion circuitry necessary to permit engineering evaluation of the spacecraft and subsystems in orbit. One telemeter, the A system, provides stored data by means of an endless-loop tape recorder; the other, the B system, provides real-time data on command.

Arrangement of the channels permits telemetry of most important test points by both systems. In addition to telemetry intelligence, the system transmits a 10-kc time-code signal for ground station synchronization purposes.

Sensing transducers throughout the structure and equipments monitor spacecraft performance with respect to temperatures, electrical and electronic systems function, and spacecraft stabilization. The telemetry conversion circuitry collects and converts these data to the telemetry format.

The A system telemeter frame consists of 64 words of 7 bits, plus a sync word which is all ones, and a word sync bit which is zero. Frame distribution is shown in Figure A-13. Word numbers 33 to 48 are subcommutated into 16 columns, providing 256 channels at a data rate of one channel per 16 seconds. The remaining 16 channels of the first row are subcommutated into 16 columns, also available at a sampling rate of one channel per 16 seconds. This provides a total of 544 channels with facility for extension by further subcommutation of the latter 16 channels. To facilitate this coding scheme, a 500-pulse-per-second bit rate is required. This stream is furnished by the master clock, or, in case of clock failure, by a tuning-fork oscillator.

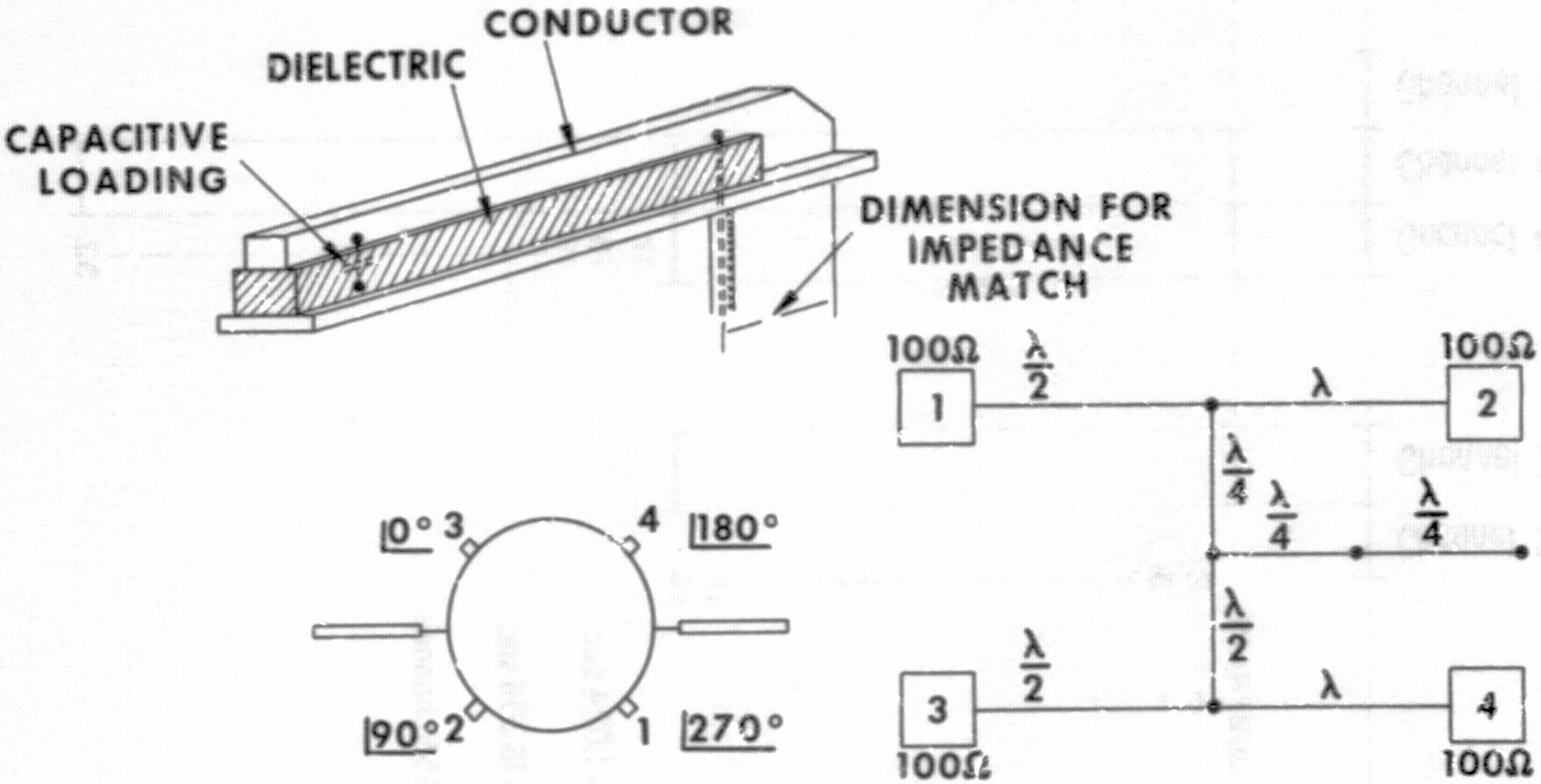


Figure A-12 – Telemetry and Tracking Antenna

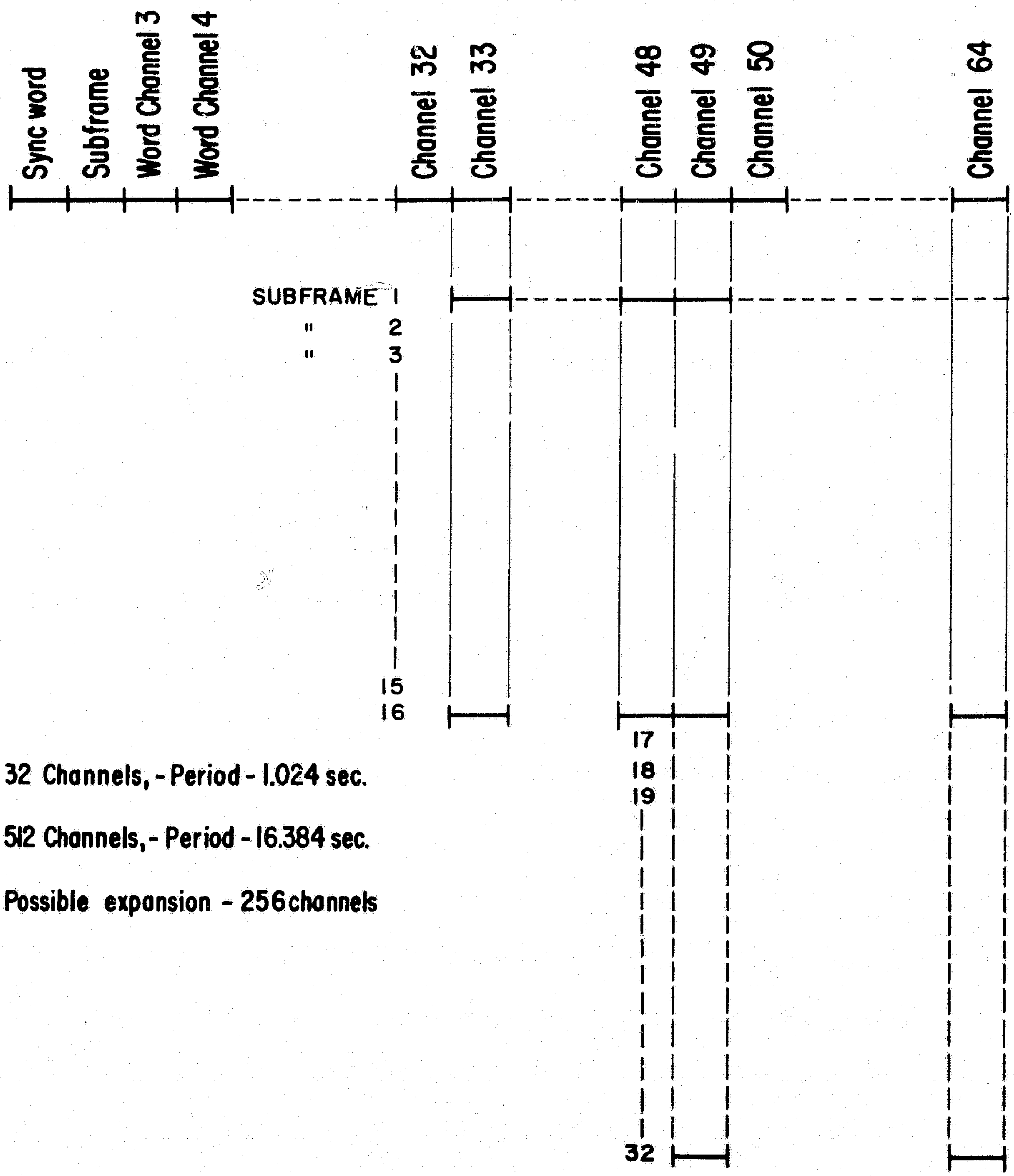


Figure A-13 – Telemetry System, Frame Distribution

The coder output modulates a coherent 500-cps subcarrier which is recorded on an endless 240-foot tape loop. The tape passes a single record-playback head at 0.4 inch per second, providing up to 2 hours of continuous recording.

Playback of the A system telemeter is by ground command. A playback speed of 12 inches per second, 30 times faster than record speed, converts the 500-cps subcarrier signal to 15 kc, covering a spectral bandwidth from very low-frequency components to 30 kc. The recorder output audio-modulates the beacon transmitter to 80 percent of its amplitude for transmission to the data-acquisition station.

The B system telemeter cycles through 128 data channels. Data points required only once per orbit at an arbitrary time are the prime constituents of the B telemetry. As with the A telemeter, a 7-bit code plus a word sync bit constitutes a word. A 10-pulse-per-second bit rate is provided by the master clock. The pulsetrain output of the coder phase-shift-keys a 5000-cps master clock subcarrier which in turn amplitude-modulates the beacon frequency upon ground command.

Figure A-14 is a functional block diagram of the Nimbus PCM telemetry logic. For A telemetry system, a 500-cps bit rate is furnished by the master clock and converted to word rate in an 8-to-1 counter. Four shift registers are driven in sequence and two shift registers in parallel with registers 3 and 4 to form a 256-position matrix. Each position of the registers and the matrices opens a gate corresponding to a particular channel, providing time-sharing multiplexing. Isolation gates are provided to prevent the failure of a signal gate from affecting more than a limited number of channels.

The multiplexer output is fed to the coder, where analog-to-digital conversion is accomplished by comparison of the input signal with a binary-weighed reference voltage. Four-stage conversion coding is performed in 50 μsec by the 200-kc bit-rate pulse. The code is then stored in a core buffer where the word sync bit is added. Additional windings on the cores provide the sync word for the subcommutation code generator. Frame sync is generated by applying maximum voltage to the analog-to-digital converter. A return-to-zero output from the coder (converted to a non-return-to-zero signal) gates a single cycle per bit of the 500-cps coherent source, which in turn drives the record head of the tape recorder.

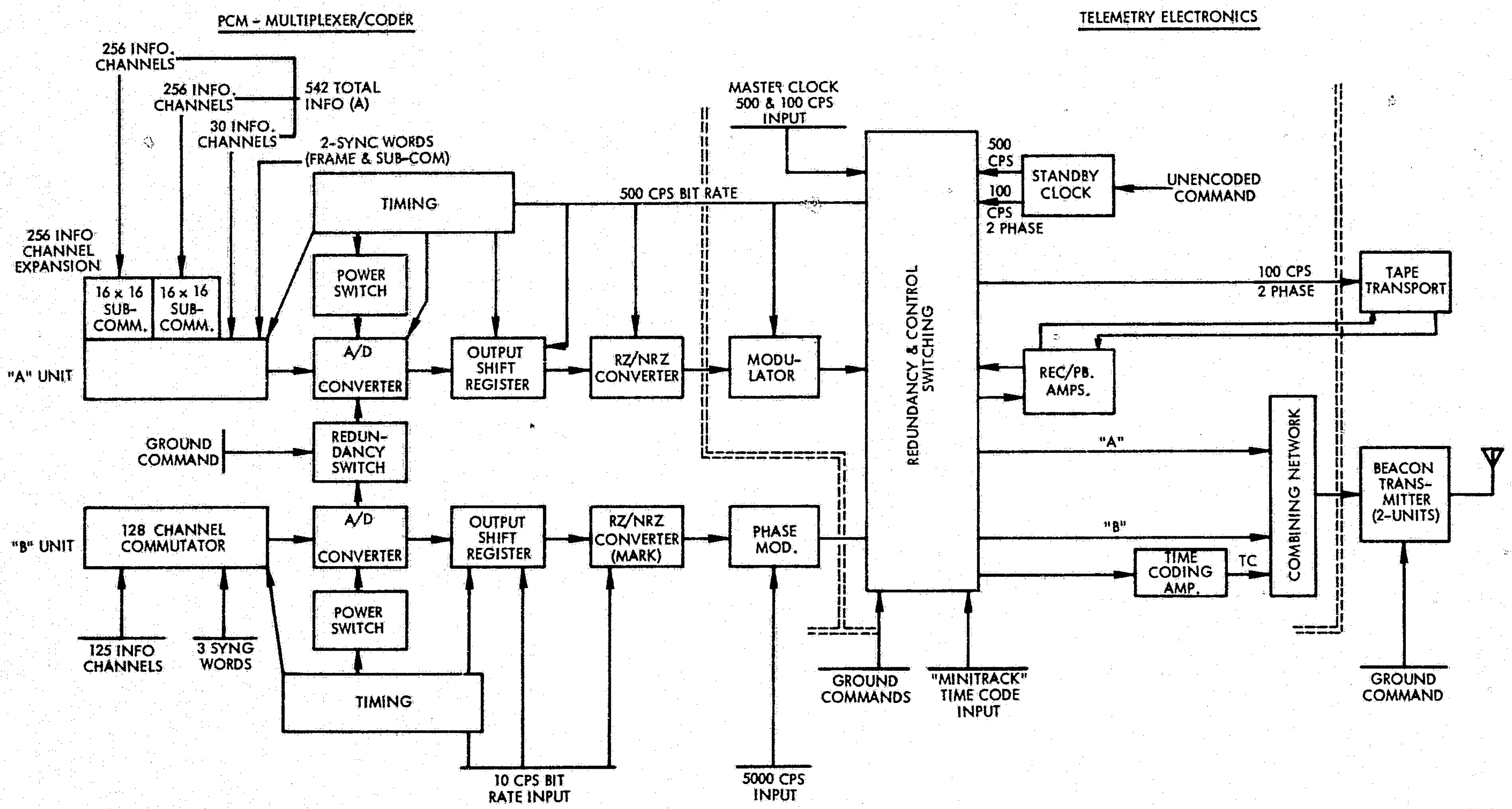


Figure A-14 – PCM Telemetry Subsystem, Block Diagram

The logic of the B system is very similar to that of the A unit; the multiplexer samples the 128 channels and feeds them through isolation gates to the coder. A parallel-to-series converter using a 10-bit-per-second clock signal for readout provides an output similar to that of system A.

The interrogation time for a spacecraft pass is approximately 10 minutes. Transmission time required for the A system is approximately 3.6 minutes per orbit; the B system pulsetrain can be transmitted in 1.75 minutes.

2.4.2 S-BAND TRANSMITTER

An S-band transmitter located in the sensory ring transmits the output of the AVCS and HRIR subsystems. The 1707.5-Mc 5-watt carrier frequency is modulated to a deviation of 1.5 Mc by the composite voltage of the frequency-multiplexed subcarriers containing the AVCS and HRIR intelligence. The S-band transmitter, transistorized with the exception of the output stage, is packaged in standard sensor-ring modules.

The S-band transmitter antenna (Figure A-15) is a cavity-backed double spiral radiator. The antenna radiates a circularly polarized wave with a 110-degree beamwidth. This pattern provides adequate coverage for readout of an average of 10 out of 14 orbits by the GILMOR station.

2.4.3 APT SUBSYSTEM TRANSMITTER

The APT subsystem transmitter, a 136.95-Mc 5.5-watt solid-state device is located in the sensory ring and transmits the video information and necessary ground equipment start and synchronization signals.

The APT subsystem transmitter employs a single quadraloop antenna mounted on the bottom of the H-frame within the sensory ring. The antenna produces a linearly polarized radiation pattern that maintains a constant satellite-antenna/ground-antenna relationship independent of their relative positions within line of sight.

2.5 COMMAND SUBSYSTEM

The Nimbus command subsystem (Figure A-16) consists primarily of a dual 122-Mc command receiver and a command decoder. Operating in conjunction with the clock subsystem, the command circuitry is capable of receiving and storing ground commands at the rate of one per second. The binary-coded ground commands provide the following functions:

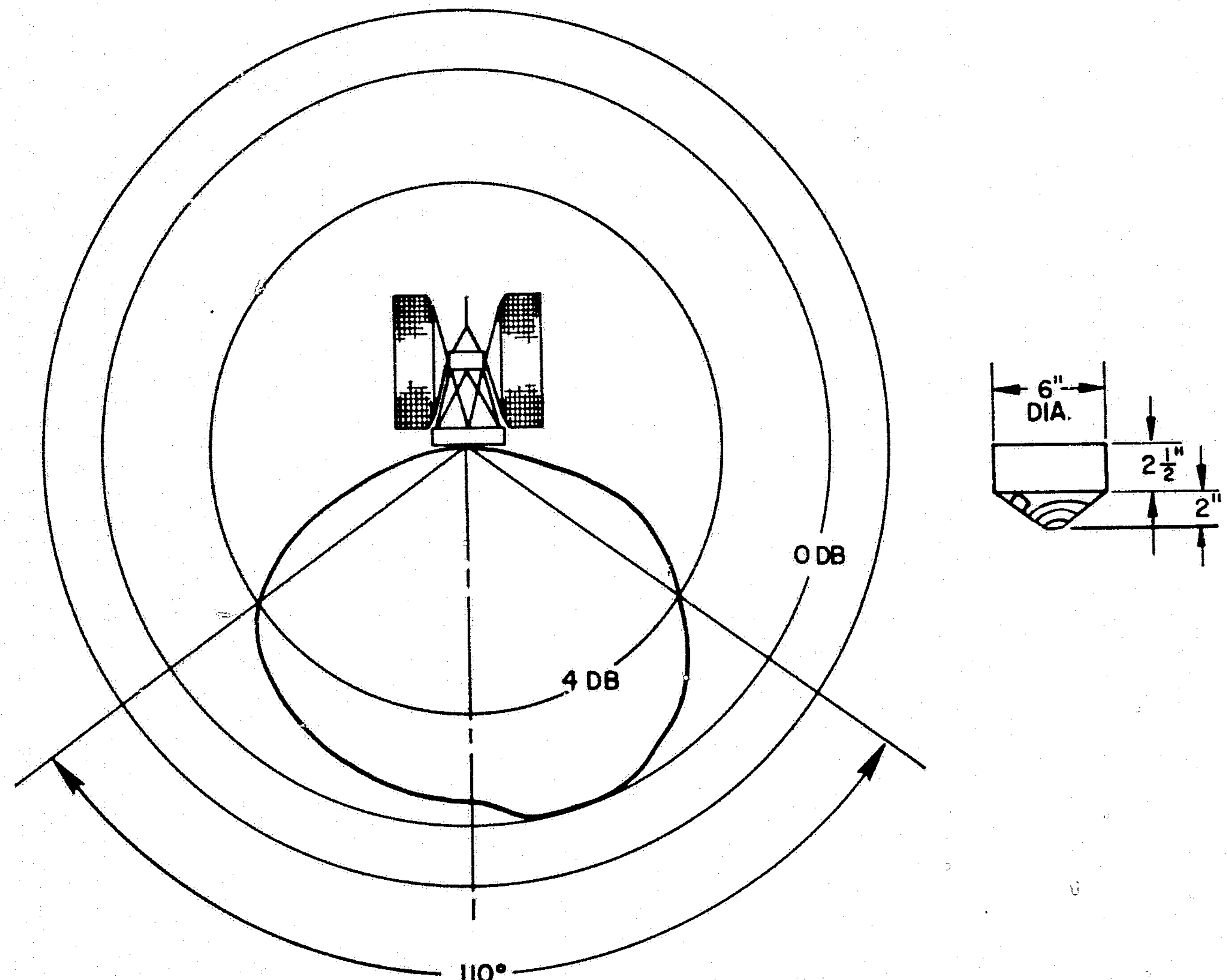


Figure A-15 – S-Band Antenna and Pattern

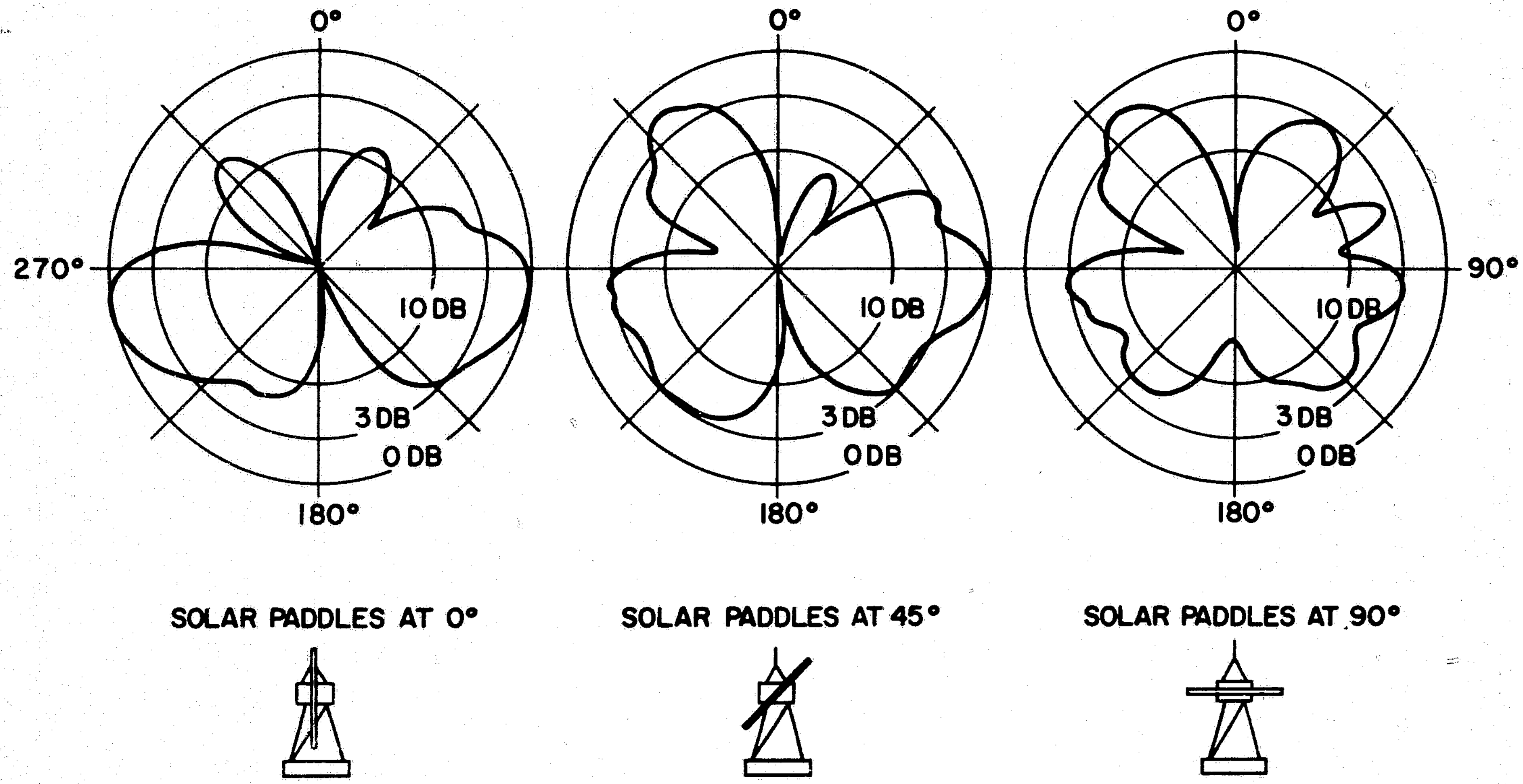


Figure A-16 – Command Antenna Pattern

- Component switching and power control for experiments and spacecraft subsystems

- Calibrating or changing control or experiment factors

- Stabilization program backup

- Interrogation

- Changing modes of operation of the communication and data-handling systems

A whip, or dipole, antenna located on top of the control housing serves the command subsystem. A conical construction on top of the control housing, and a conical skirt extending about two-thirds of the way down the truss structure from the control housing, give the satellite the electrical appearance of a cone. This configuration is used to improve the decoupling between the solar paddles and the whip antenna.

2.6 THERMAL CONTROL

A combination of active and passive thermal-control techniques provides acceptable average temperatures throughout the spacecraft. With the exception of the solar paddles, an average temperature of approximately 25° ± 10°C is maintained.

The Nimbus configuration provides thermal separation and permits independent thermal control for each major segment of the spacecraft: solar paddles, sensory ring, and control system.

2.6.1 SOLAR PADDLES

The solar array is designed to provide cell temperature excursions consistent with solar-cell conversion efficiency. Proper solar-cell temperatures are maintained through a passive arrangement of reflection filters and high-emittance surfaces. The absorptivity/emissivity ratio is selected to maintain the solar paddles at an average temperature of 25°C. The honeycomb structure of the paddles provides excellent thermal conductivity between surfaces in that the side opposite from the sun tends to cool the heated side, thus minimizing temperature gradients.

2.6.2 SENSORY RING

The base ring of the sensory ring serves as a heat sink for the electronic modules. Conduction paths to the ring are provided for equipment mounted on the crosswebs within the ring. An active system of

controlled louvers (Figure A-17) provides actual temperature control; the louvers, located around the periphery of the ring, open to permit heat loss by the high-emittance radiating surface. The louvers are controlled by freon-filled bellows located between the modules and connected to thermal-control sensing panels. Temperature changes are detected by the panels and transmitted thermally to the bellows which operate the louvers through a mechanical linkage arrangement. The temperature-control system operates between 12°C and 27°C, providing a simple dependable self-regulating thermal system. Fail-safe features, which return the louvers to the midrange position in case of gas leakage or bellows failure, add further dependability.

2.6.3 ATTITUDE CONTROL SUBSYSTEM

The control subsystem structure employs both active and passive thermal control to maintain temperatures within acceptable limits.

Active thermal control consists of two louvered panels (Figure A-18) similar in action to those of the sensory ring. The panels are located on the control housing above each solar-paddle driveshaft. The sensors, located between the louvers and the radiating surface, control the opening and closing of the louvers in response to temperature changes of the radiating surfaces.

2.7 ADVANCED VIDICON CAMERA SUBSYSTEM (AVCS)

The AVCS consists primarily of a bank of three synchronized TV cameras and a magnetic tape-recording system.

The three TV cameras, deployed in a fan-like array, produce a three-segment composite picture. Each camera covers a 37-degree field-of-view. The center camera points straight down (local vertical). The optical axes of the second and third units are rotated 35 degrees to the right and left of local vertical. This arrangement produces a composite picture 107 degrees by 37 degrees, providing the lateral field-of-view (with 2 degrees overlap at the equator) necessary to cover the 26-degree rotation of the earth between spacecraft passes; the 26-degree rotation of the earth produces approximately 1560 nautical miles of arc at the equator.

A timer programs the camera bank to take a picture every 91 seconds, the time required (including a 5-percent picture overlap) for the spacecraft to traverse from picture center to picture center. Longitudinal coverage of the illuminated portion of each orbit is thus provided by a series of 30 pictures taken by each of the three cameras.

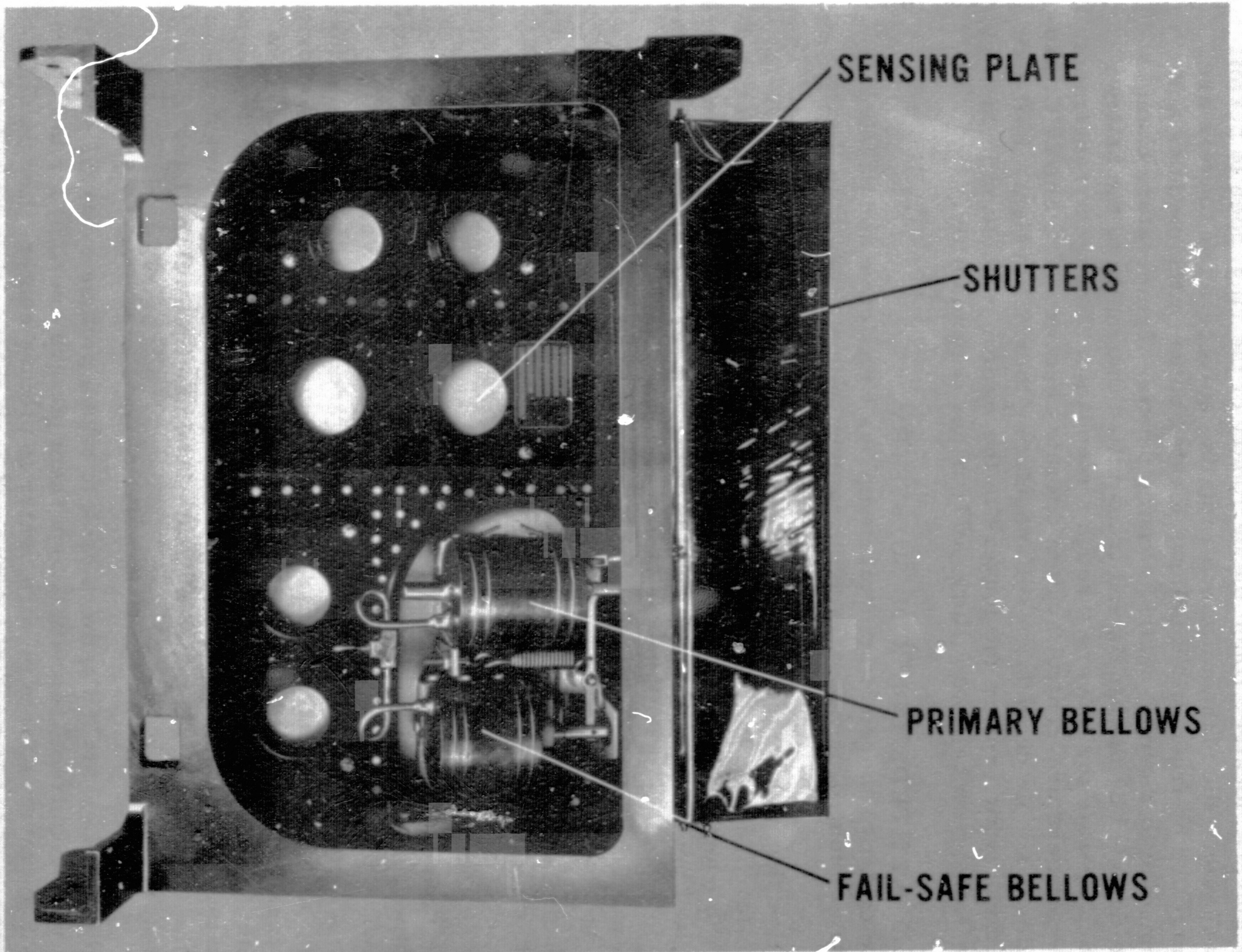


Figure A-17 – Sensory Ring Module Temperature Controller

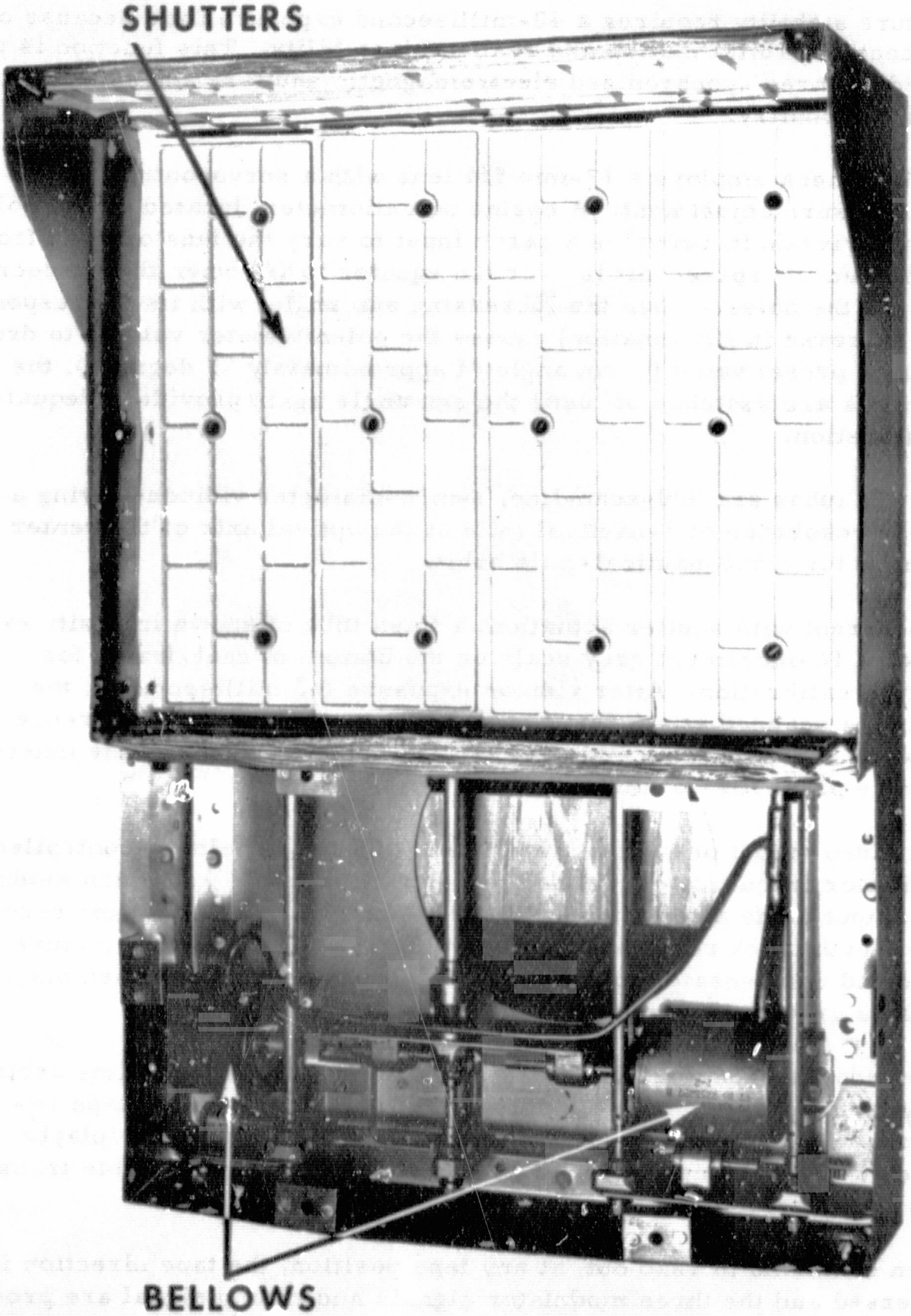


Figure A-18 – Attitude Control Subsystem Temperature Controller

Picture stability requires a 40-millisecond exposure time because of spacecraft orbital motion and residual instability. This function is provided by three synchronized electromagnetic shutters and appropriate timing circuitry.

Each camera employs a 17-mm f/4 lens with a servocontrolled iris for exposure adjustment. A cosine potentiometer, located on the solar-array driveshaft, provides a servo input to vary the lens opening from f/16 when the spacecraft is over the equator to f/4 when the spacecraft is near the poles. When the increasing sun angle, with its corresponding decrease in illumination, causes the potentiometer voltage to drop below a preset value (a sun angle of approximately 85 degrees), the cameras are switched off until the sun angle again provides adequate illumination.

The TV tubes are 800-scan-line, 1-inch-diameter vidicons giving a linear resolution of 1-nautical mile at the optical axis of the center camera for a 500-nautical-mile orbit.

Concurrent with shutter actuation, a flash tube of known intensity exposes a 16-increment grey scale on the bottom of each frame for picture calibration. After vidicon exposure (40 milliseconds), the image is scanned at a 6.5-second-per-frame rate. (The difference between exposure time and scan time is accommodated by the inherent storage properties of the vidicon.)

The video output of each camera is fed to a 96-kc voltage-controlled oscillator frequency-modulated to a deviation of ±24 kc. Each modulator output feeds a separate head and track of a four-track tape recorder. The fourth track records a 50-kc timing signal that defines picture time and compensates for tape-recorder wow and flutter when played back on ground equipment.

The recorder contains enough tape for recording two complete orbits (64 frames per camera); a limit switch is used to stop the tape recorder when the tape is completely filled. A 30-ips record/playback speed permits complete two-orbit readout within the available transmission time.

Upon command to read out, at any tape position, the tape direction is reversed and the three modulator signals and timing signal are processed to generate a frequency-multiplexed signal which is summed with the output of the HRIR for transmission by the S-band transmitter.

2.8 HIGH-RESOLUTION INFRARED RADIOMETER (HRIR) SUBSYSTEM

The HRIR is designed to produce high-resolution cloud-cover pictures of the dark side of the earth. In contrast to television, the HRIR (Figure A-19) forms no image; the detector only integrates the energy received from the earth and atmosphere (clouds). Cloud-cover pictures are composed as follows: A rotating scanning mirror causes the detector view to continuously sweep through a complete circle. The radiometer is located on the spacecraft so that the plane described by the optical axis is normal to the instantaneous velocity vector. The scan time of the mirror is selected to coincide with the time required for the spacecraft to advance the width of a picture element; the lines thus scanned form a continuous picture (Figure A-3).

The HRIR is designed for an angle of view of 7.8×10^{-3} radians. It is sensitive in the 3.4- to 4.2-micron region and scans at 0.83 cps, yielding 560 elements over the 120-degree angle from horizon to horizon, achieving a 5.1-nautical-mile (8.5-km) linear resolution at scan center (local vertical).

In operation, the radiation is mechanically chopped (to avoid dc amplifiers and dependence on detector bias stability) and applied to a lead selenide detector, which is radiation-cooled to -70° ± 10°C. The resulting ac signal is amplified and rectified, producing a video bandwidth from dc to 280 cycles per second. During the sky-spacecraft-sky portion of the sweep, a permanent magnet on the mirror axis initiates seven pulses which synchronize ground and the spaceborne equipment.

The HRIR output frequency-modulates a 10-kc voltage-controlled oscillator 2.5 kc; a tape recorder similar in design to the AVCS recorder records the resulting signal. The radiometer signal and a 10-kc timing signal from the master clock drive two heads of a four-track recorder until the complete length of tape is used, when the signals are switched to the remaining tracks and the tape reverses direction. The recorder records continuously except during playback, erasing immediately before recording. Upon interrogation all four tracks play back simultaneously at 30 ips, eight times the 3.75-ips recording speed. Local oscillators and mixers generate a frequency-multiplexing spectrum that is transmitted by the S-band transmitter.

2.9 AUTOMATIC PICTURE-TRANSMISSION (APT) SUBSYSTEM

The APT subsystem (Figure A-20) employs the same basic principles as the AVCS. However, in contrast to the AVCS, which stores pictures

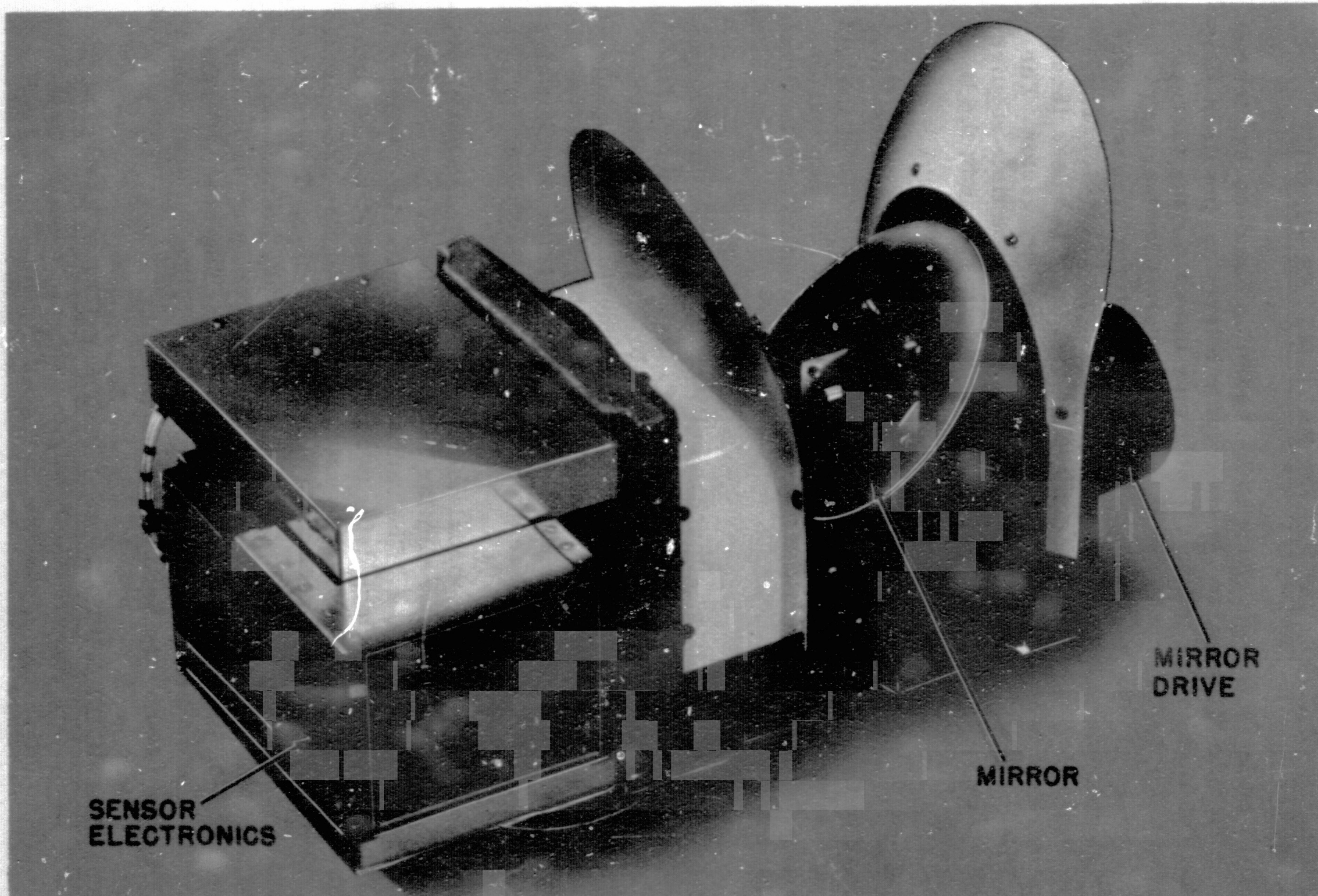


Figure A-19 – HRIR Housing

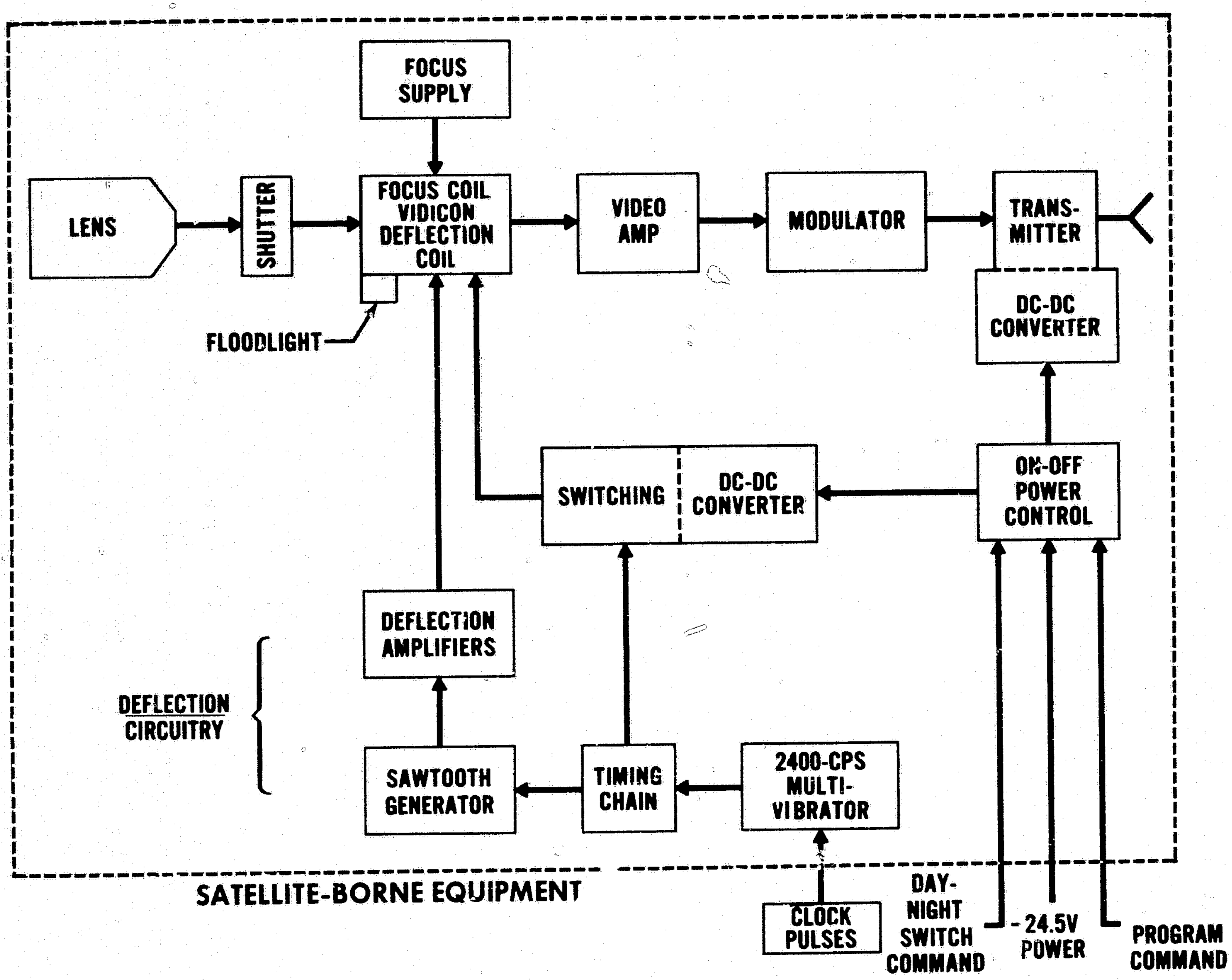


Figure A-20 – APT Subsystem, Block Diagram

on tape for transmission on ground command, the APT subsystem wide-angle cloud-cover pictures are taken and transmitted in real time to local ground stations for immediate use.

A timer programs the equipment for continuous cycles of prepare, expose, develop, and direct-readout for approximately 30 minutes of each orbit. Cycle time (208 seconds) combined with camera field-of-view (108 degrees) provides overlapping (32 percent) longitudinal real-time cloud-cover picture coverage (Figure A-4). The camera takes pictures continuously throughout the sunlit portion of each orbit. Each picture will cover a ground area of 1050 by 1050 nautical miles, with a north-south overlap of 300 nautical miles between adjacent pictures.

The APT subsystem consists of four major elements: the sensory housing (Figure A-21) containing the camera, vidicon, and vidicon electronics; the video electronics module, made up of the video detector, timing and switching circuitry; power converters; and the APT FM transmitter. A 5.7-mm f/1.8 Tegea Kinoptic wide-angle (108 degrees) lens is used in conjunction with an electromagnetic shutter to expose (40 milliseconds) an 800-scan-line 1-inch-diameter vidicon.

The vidicon (Figure A-22) is similar to the TV vidicon except for the addition of a polystyrene layer to provide extended image storage capability. The tube is operated through the prepare, expose, develop, (PED), and readout phases by varying the mesh potential with respect to the target potential; i.e., the image is projected on a "prepared" photoconductive layer, then transferred by potential change to the polystyrene storage layer for readout. The prepare, expose, and develop operations are accomplished during the first 8 seconds of each 208-second picture cycle; the remaining 200 seconds are required for readout at a scan rate of 4 lines per second.

The vidicon output is amplified and the amplifier output (consisting of amplitude-modulated pulses) is applied to the video detector. Detection produces a continuous analog readout which in turn amplitude-modulates a 2400-cps subcarrier to produce a double sideband-modulated subcarrier extending across 1600 cycles. The modulated subcarrier frequency-modulates the 136.950-Mc APT transmitter.

3. GROUND STATION VANS

The equipment installed in the ground station vans at PMR is listed below.

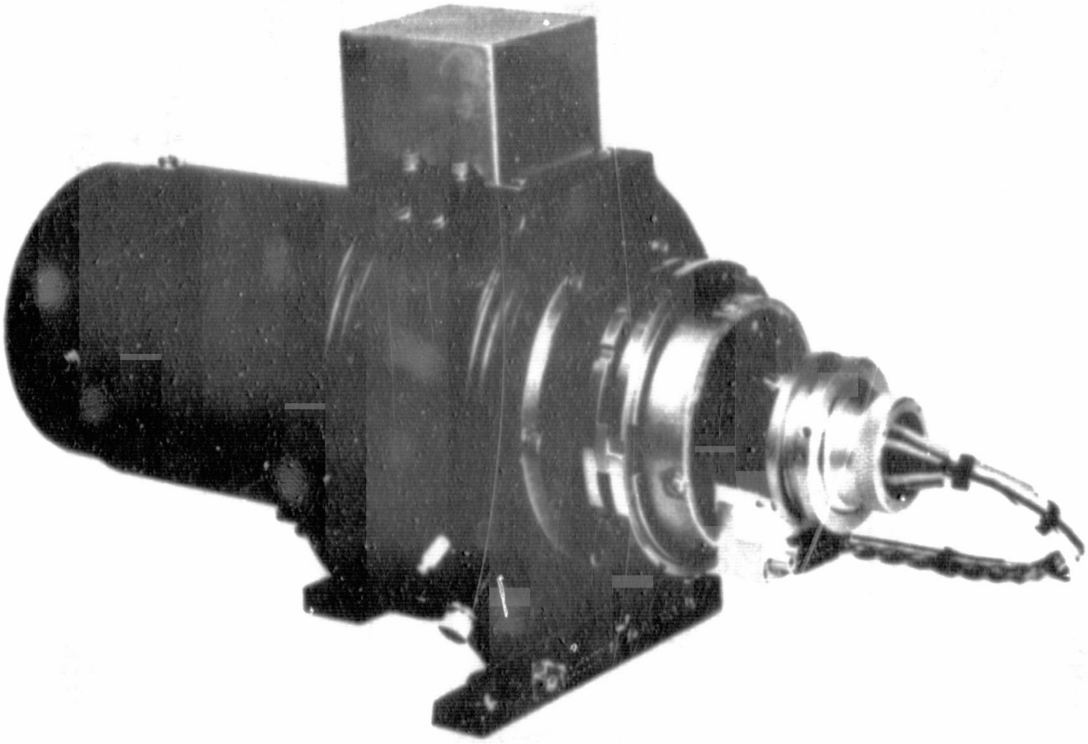


Figure A-21 – APT Sensory Housing

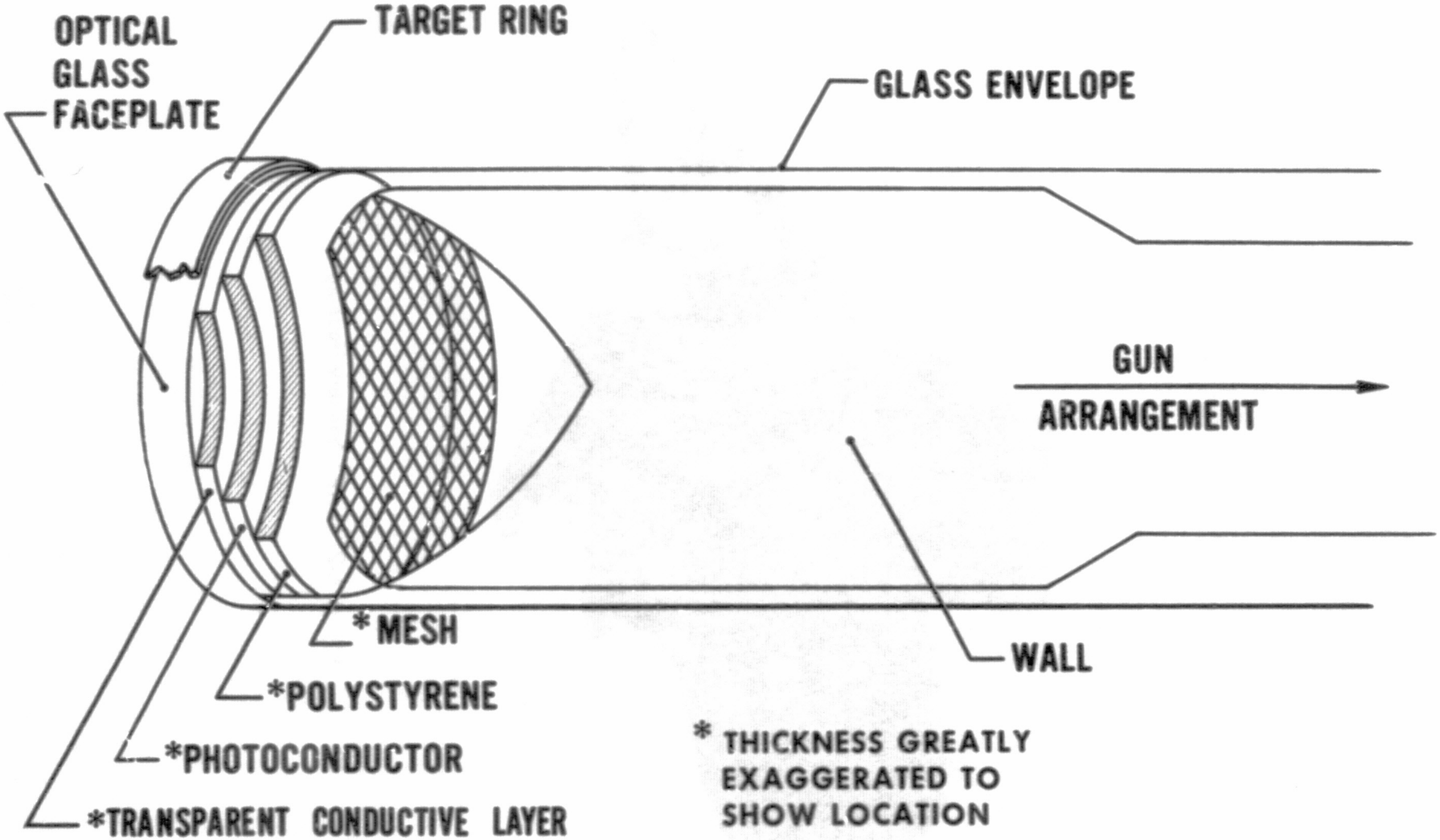


Figure A-22 – APT Vidicon, Cutaway Drawing

3.1 VAN 1 - PCM/COMMAND VAN

Van 1 contains PCM telemetry equipment that is used for receiving telemetry information from the spacecraft and the command system used to send commands to the spacecraft.

- Command Clock System
  - Modulator Printer Bay Assembly (Cal Comp)
  - Reader Perforator Bay Assembly (Cal Comp)
  - Control Console Bay Assembly (Cal Comp)
  - Clock and Transmitter Bay Assembly (Cal Comp)
  - Minitrack Time Code Generator (NASA)

- PCM Telemetry System
  - Printer CDC 1612 (Radiation/CDC)
  - Computer CDC 160A (Radiation/CDC)
  - Tape Recorder CDC 16422 (Radiation)
  - Decommutation Assembly (Radiation)
  - Brush Recorder Assembly (Radiation)

- VHF Antenna Control Rack

3.2 VAN 2 - AVCS/HRIR AND APTS VAN

Van 2 contains the ground equipment for the AVCS/HRIR/APT systems.

- AVCS/HRIR System

- Minicom Recorders (RCA)
  - Receiver Rack (RCA)
  - Kine Circuits Rack A
  - Power Supply and AC Distribution Rack (RCA)
  - Storage Rack
  - AVCS Index Computer (RCA)

- APT System (RCA)

4. AEROSPACE GROUND EQUIPMENT (AGE)

The AGE to be supplied by GE at PMR is:

1. Spacecraft cover sling (1 per s/c)
2. Spacecraft dolly sling and balancer (1 per s/c)
3. Spacecraft cover (1 per s/c)
4. Spacecraft test and calibration dolly (1 per s/c)

5. Spacecraft transport trailer (1 per s/c)
6. Flight adapter handling assembly (2)
7. Mechanic's tool kit (2)
8. Spacecraft cleaning kit (1)
9. Spacecraft access platforms/ladders (2 sets)
10. Cover mounting ring (2)
11. Utility dolly (2)
12. Spacecraft humidity cover (1)
13. Control subsystem and sensory ring check of alignment (1)
14. Surface plate (1)
15. Spacecraft lift sling (1)
16. Hydra set (1)
17. Agena/adapter interface tool (2)
18. Separation spring inspection fixture (1)
19. Leak test equipment (1)
20. Gas-charging hose assembly (2)
21. Paddle hub clamps and deployment support fixture (1)
22. Check-of-calibration adapter alignment equipment (1)
23. Load cell monitor (1)
24. Blockhouse launch console load simulator (1)
25. Solar paddle continuity test rack (1)
26. Test cables (2 sets)
27. Antenna carrier (1)
28. NIMCO/NIMIT integration test console (1 - at S/L Lab)
(1 - at Blockhouse)
29. Launch site operational console (1 - at S/L Lab)
30. S-band preamplifiers (2)
31. Constant voltage transformer (1)
32. Line resistance simulation box (1)
33. Target control rack (1)
34. Battery charge/discharge and squib monitor (1 set)
35. Spacecraft test connectors (1 set)
36. Accountability kit (1)
37. Spacecraft and shroud clearance tools (1 set)